

R E P O R T R E S U M E S

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GENERAL MECHANICS, A COURSE OF STUDY DESIGNED FOR COOPERATIVE PART-TIME STUDENTS EMPLOYED IN GENERAL MECHANICS SHOPS.

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DESCRIPTORS- *STUDY GUIDES, *CURRICULUM GUIDES, *MECHANICS (PROCESS), HIGH SCHOOLS, POST SECONDARY EDUCATION, *TRADE AND INDUSTRIAL EDUCATION,

THE PURPOSE OF THIS COMBINATION COURSE OF STUDY AND STUDY GUIDE IS TO PROVIDE MATERIAL FOR JOB SKILLS AND PROCEDURES, TECHNICAL INFORMATION, AND PERSONAL DEVELOPMENT. USE IN GRADE 11 OR ABOVE IS RECOMMENDED FOR COOPERATIVE OR PREPARATORY COURSES. IT WAS ORIGINALLY WRITTEN BY A RESEARCH ASSISTANT, REVISED BY A RESEARCH ASSISTANT IN A UNIVERSITY SETTING, WITH ADVICE FROM AN ADVISORY COMMITTEE AND SPECIALISTS, AFTER EXTENSIVE USE. COURSE CONTENT IS PRESENTED AS "WHAT THE WORKERS SHOULD BE ABLE TO DO" AND "WHAT THE WORKER SHOULD KNOW." COVERED ARE SUCH AREAS AS (1) SMALL GAS ENGINES, (2) CHAIN SAW SHARPENING, (3) OUTBOARD MOTORS, (4) BICYCLES, AND (5) DUPLICATION OF KEYS. ASSIGNMENT SHEETS, TESTS, AND INFORMATION SHEETS COMPRISE THE STUDY GUIDE. PROGRESS RECORDS FOR THE INSTRUCTOR AND EMPLOYER ARE PROVIDED. RELATED INSTRUCTION REQUIRES 180 CLOCK HOURS. A QUALIFIED COORDINATOR OR COMPETENT GENERAL MECHANICS INSTRUCTOR IS NECESSARY. THE STUDENTS SHOULD BE AT LEAST HIGH SCHOOL JUNIORS WITH MECHANICAL APTITUDE. LISTED ARE 11 REFERENCES, 17 SOURCES OF MATERIALS, AND TWO PUBLISHERS. AN ANSWER BOOK (VT 002 082) IS AVAILABLE. REPRODUCTION OF THIS 8 BY 11 INCH GUIDE IS BY MIMEOGRAPH. THIS DOCUMENT IS AVAILABLE FOR \$1.50 FROM INDUSTRIAL EDUCATION, 103 INDUSTRIAL EDUCATION BUILDING, UNIVERSITY OF MISSOURI, COLUMBIA, MISSOURI 65201. (EM)

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GENERAL MECHANICS

A Course of Study

Designed for
**Cooperative Part-Time Students
Employed in General Mechanics Shops**

Issued by
**Department of Industrial Education
College of Education
University of Missouri
Columbia, Missouri**

In Cooperation with
**Industrial Education Section
State Department of Education
Jefferson City, Missouri**

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FOREWORD

This course of study, consisting of an analysis of GENERAL MECHANICS, together with assignment sheets covering the related (occupational) information to be taught by the school, has been prepared for teaching general mechanics on an individual basis in part-time Cooperative Occupational Education programs.

The original course of study was prepared by Dr. M. D. Williamson, formerly Research Assistant in Industrial Education. The present revision of the analysis and assignment sheets was prepared by Mr. Jack A. Luy, Research Assistant in Industrial Education at the University of Missouri.

We wish to acknowledge our indebtedness to Dr. H. H. London, Professor of Industrial Education at the University of Missouri, for the direction and administration of the Curriculum Materials Laboratory in which this material was prepared, and to Mr. James B. Karnes, Instructor in Industrial Education at the University of Missouri, who supervised the preparation of the material and edited the manuscript. Credit is due to Dr. H. Pat Wardlaw, Assistant Commissioner of Education, Mr. Merton Wheeler, Director of Industrial Education, and to other staff members of the State Department of Education for their efforts in the development of the Industrial Education Curriculum Series of which this course of study is a part.

HUBERT WHEELER

Commissioner of Education

August, 1963
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Training Plan and Progress Record

INTRODUCTION

In preparing this course of study, it has been assumed that the attainment of occupational competency in any type of work involves three different, yet closely related, types of learning. They are:

1. Mastery of the practical job skills and procedures performed by the worker in the occupation.
2. Comprehension of the technical and related information basic to an intelligent understanding and practice of the occupation.
3. Development of those personal-social traits which are essential for the successful worker.

The first group of these "learning units"--the job skills and procedures--has been arranged in the analysis under the heading of "Job Training." The second group of learning units--the technical and related information--has been arranged under the heading of "Related Information." And the third group--the personal-social traits--has been listed under "Personal-Social Traits Essential for the General Mechanic" in the introductory section addressed to the student.

In a cooperative educational program it is necessary for both cooperating agencies--the school and the employer--to understand clearly just what each is to be responsible for in the training of the student-worker. Experience has shown that most of the practical job skills and procedures of an occupation can best be learned through supervised work on the job. Experience has shown also that the school can best teach most of the technical and related occupational information needed by young student-workers. This division of responsibility has been made in the arrangement of the course of study; that is, it is expected that the student-worker will master the job skills and procedures through practical work on the job under the immediate supervision of the employer, and that he will receive instruction in related occupational information in the school under the direction of the coordinator.

Skills and related information are matters for direct instruction but personal-social traits are acquired only through practicing them during the process of acquiring skills and information and in one's daily conduct. Therefore, both the employer and school, as well as the home, must assume responsibility for developing in the student-worker those habits, attitudes and character traits which are essential for success in his occupation and in life. Both the employer and the school should be constantly on the alert to see that the student-worker places desirable interpretations on his experience and that he does not practice habits and exhibit character traits detrimental to his success.

Since the coordinator's class will be made up of fifteen or more students, each differing from the other significantly, studying a dozen or more occupations which differ markedly in their requirements, it follows that it will be impossible for him to teach, through the group method, the occupational information which relates to the specific job of each student-worker. In order to be effective, this type of instruction must be individualized. There is, of course, some related information, such as occupational health and safety, workmen's compensation, wage-hour laws, fair labor standards, unemployment compensation, and the like, which is of common interest and concern to all student-workers, and may be effectively taught by the group method. But if the coordinator is to make a real contribution to the in-service vocational education of his students, he must devote a major portion of his classroom instruction to content which deals specifically with the work of each boy and girl enrolled.

With this requirement in mind, and in order to facilitate individual instruction, these assignment sheets have been prepared. Each contains certain record data as to number and range of units covered, introductory paragraphs designed to develop interest, explain the importance of the assignment, and to convey to the student what he is expected to learn, specific assignments including reading, learning activities and a series of new-type questions designed to check his attainment.

Obviously, it is desirable to teach the related information in the school at the time it will be used most advantageously on the job. This means that the two phases of the student-worker's training should parallel each other in a progressive manner. The coordinator will find the assignment sheets well adapted to this end. He can select from day to day the assignment which covers the informational units related to the work being done on the job. With this arrangement, the coordinator will use a major portion of his classroom time in supervising and aiding individual students in their study.

In selecting books for the course, an effort has been made to restrict the number to an adequate coverage of the material, and to select those of recent publication so that current practices can be consistently presented. It is recommended that copies of these books be secured and kept in the coordinator's classroom for ready use by the student.

The key sheets, available in a separate manual, have been prepared to enable the coordinator to score quickly the objective tests which are a part of each assignment sheet. These key sheets give the correct answers to the questions, as well as the reference and the page on which each answer can be found. The key sheets should be kept in the coordinator's possession.

TO THE STUDENT-WORKER

The general mechanic's trade is a service type of trade which is concerned with many aspects of mechanics. Although the general mechanic will be required to do other things, he will need to develop special skills in repair of gasoline engines, lawn mowers, chain saws, outboard motors, lower units, bicycles, and in the less complicated phases of key duplicating and lock work. It can readily be seen that an all-around knowledge of mechanical principles must be gained if success is to be expected. The general mechanic must become specialized in a number of things rather than in one phase. But to be a good repairman one must acquire much more than mechanical skills.

Personal-Social Traits Essential for the General Mechanic

Personality traits are of extreme importance, not only in securing and holding a desirable position, but in life in general. Personal and social traits can be improved through training when the individual learns what to improve, how to improve and why improvement is advisable. Among the personal-social traits of chief importance to the general mechanic are the following.

Patience - Much of the work of the general mechanic is in "hard-to-get" places, and it requires patience as well as skill to make the necessary adjustments and repairs.

Personal Appearance - Clothing should be worn that is conducive to efficiency, and a pleasing impression upon the people you serve.

Good Physical Condition - Physical requirements are not excessive, but the conditions of work are not always ideal. Often it is necessary to work in cold, drafty, and poorly ventilated places. One must be in good physical condition to keep at top efficiency. One must have good muscular coordination, mechanical dexterity, good eyesight, and steady nerves.

Cooperation - A general mechanic must possess a willingness to work cooperatively with fellow workers. This means an attitude of readiness to assist others when they need help, and to join in group undertakings.

Consideration of Others - A thoughtful attitude toward making things easy and pleasant for others, such as keeping things in order, putting tools away, and doing your full share of work is an important marketable trait of a good repairman.

Industry - This character trait means a habit of a careful, thoughtful, and energetic attack upon the job without loitering or wasting time.

Initiative - The ability to see what needs to be done and go ahead without constant supervision is an essential trait of a repairman.

Reliability and Trustworthiness - Intrusted in your care are not only the security and safety of your customer but also to some extent his financial well-being. Your customer will rely on you to do the very best job of which you are capable at a fair price and to stand behind your work.

REFERENCES

- A. Purvis, Jud, All About Small Gas Engines, Goodheart-Willcox Company, 18250 Harwood, Homewood, Illinois, 1960. \$4.50 (10)**
- B. Lawn-Boy Mechanic's Handbook, Lawn-Boy Corporation, Galesburg, Illinois. \$1.50 (8)**
- C. McFarlane, John W., It's Easy to Fix Your Bike, Follet Publishing Company, 1010 West Washington Blvd., Chicago 7, Illinois, 1958. \$3.20 cloth bound, \$1.25 paper bound. (4)**
- D. Temple Press Limited, Cycling Book of Maintenance, Temple Press Ltd., London, England, Fifth Edition. (Missouri schools will be furnished a free copy with the purchase of a course of study. Out-of-state schools may obtain copies by writing Mr. Hillary Watts. The British Cycle and Motor Cycle Industries Association, Ltd., 20/23 Lincolns Inn Fields, WC2, London, England--cost about \$.85. (4)**
- E. Kraynick, Steve, Bicycle Owners' Complete Handbook, Floyd Clymer Publishers, 1268 S. Alvarado Street, Los Angeles, California. \$1.00* (3)**
- F. Fate-Root-Heath Company, Operating Instructions for the Model 900 Lawnmower Sharpener, Plymouth, Ohio. (2)**
- G. Evinrude Motors, Evinrude Service Manual, Fifth Edition, Milwaukee 16, Wisconsin. \$5.00*** (1)**
- H. Fate-Root-Heath Company, Operating Instructions for the Peerless Saw Chain Grinder, Plymouth, Ohio. \$.50. (1)**
- J. Johnson Motors, Propellers, RPM, and Performance, Waukegan, Illinois. *** (1)**
- K. Long, Kenneth (ed.), Small Engines Service Manual, Sixth Edition, Technical Publications, Inc., 1014 Wyandotte Street, Kansas City, Missouri. (1)**
- L. National Key Company, How to Duplicate a Key, 5777 Grant Avenue, Cleveland 5, Ohio, 1959. (Schools may obtain single copies free by using school letterhead.) (1)**

* Subject to educational discount

** Frequency of use in assignments

*** Note: This reference needed only if student is training in outboard motor repair and maintenance. Copies of Service Manual may be purchased from Evinrude Motor or perhaps a copy can be obtained for use from a local Evinrude dealer or repairman.

SOURCE MATERIALS FOR POWER MECHANICS

(Coordinator may obtain materials by writing the following companies)

Briggs and Stratton Corporation
2711 North 13th Street
Milwaukee 1, Wisconsin
***Course Outline

Clinton Machine Company
Maquoketa, Iowa

Continental Motors Corporation
12800 Kercheval Avenue
Detroit 15, Michigan
c/o Martin Kennedy
Sales and Service Rep.
Mechanics Manual

Cushman Motor Works, Inc.
Lincoln 1, Nebraska
c/o Clark A. Springman
*Printed materials available
from local dealers (manual).
About address for other
material.

Evinrude Motors
Milwaukee, Wisconsin
c/o Richard Bayley
Service and Promotion Manager
Nominal fee and mailing
charge, Cutaway charts,
manuals, catalogs, etc.

Johnson Motors
Waukegan, Illinois
c/o Arvid Olson
Service Promotion Manager
Training aid packet \$25.00.
Excellent material--well
prepared.

Kiekhaefer Corporation
Publications Department
111 East Burnett Street
Beaver Dam, Wisconsin
c/o George A. Richardson
Service training charts,
manuals, etc.

Kohler Company
Kohler, Wisconsin
c/o F. W. Nelson
Engine and Electrical Plant
Sales Department

Lawson Engine Division
Tecumseh Products Company
Parts Department
Grafton, Wisconsin
c/o William A. Kammerer
Assistant Service Manager
Motor Manuals

Lawn-Boy
Galesburg
Illinois
Factory Parts and Service Mgr.
Manuals

Lawn Mower Institute, Inc.
307 Mills Building
Washington, D. C.
**Bulletin listing power
mechanics aids, engines
textbooks, etc.
Bulletin on tool lists
**Bulletins on power lawn
mower safety.

Mustang Motorcycle Corporation
635 West Colorado Boulevard
Glendale 4, California
(for Gladden engines)

Power Products Corporation
Grafton, Wisconsin

Racine Vocational & Adult School
800 Center Street
Racine, Wisconsin
*\$.25 for Pilot Course
Outline on Small Engine
Repair.

Sears, Roebuck and Company
Chicago 7, Illinois
Department 606
(Elgin Outboards)

Wisconsin Motors Corporation
Milwaukee 46, Wisconsin
c/o Richard Charles
Sales Department
Engine Manuals

West Bend Aluminum Company
Engine Division
Hartford, Wisconsin
c/o Vernon F. Mayer
Field Service Manager
Engine Manual

Note: Some of the sources listed here provide free** printed materials but all of them provide materials at cost or at a nominal handling charge to schools. This list does not include all of the sources of small gasoline engines.

TEXTBOOKS

The following publishers are suggested as sources for additional textbooks in the area of power mechanics:

Goodheart-Willcox Company, Inc.
1322 South Wabash
Chicago 5, Illinois

Charles A Bennett Company
Peoria
Illinois

Note: This list is not inclusive and there may be other publishers who have new books in this field.

ANALYSIS OF GENERAL MECHANICS

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
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SMALL GAS ENGINES

The Engine

	1	1. Uses of small gasoline engines
	1	2. Engine Design
	1	3. Engine cylinder arrangements
	1	4. Types of Engines
5. Measure cylinder diameter	1	5. Cylinder design and function
	1	6. Kinds of power measurement
	1	7. Factors determining power
	1	8. Combustion chamber design and function
9. Wire spark plugs for proper firing order	1	9. Firing orders of engine
10. Remove and clean piston	2	10. Piston and ring design and function
11. Inspect and measure piston for wear		
12. Install piston skirt expander		
13. Fit rings to cylinder	2	13. Kinds of rings
14. Insert piston and rings in cylinder		
15. Remove connecting rod	2	15. Connecting rod design and function
16. Check inserts for wear		
17. Replace inserts		
18. Install connecting rod and check alignment		
19. Remove piston pin, bushings, and locks		
20. Replace bushing and ream to fit piston pin		
21. Check rod for warpage		
22. Remove and replace crankshaft	2	22. Crankshaft design and function
23. Adjust crankshaft end play		
24. Check crankshaft for wear		
25. Remove and replace main bearings or inserts		

JOB TRAINING: What the Worker Should be Able to Do		Assign. No.	RELATED INFORMATION: What the Worker Should Know
26.	Fit main bearings		
27.	Remove and replace fly wheel	2	27. Design and function of fly wheel
28.	Remove and clean cylinder head	2	28. Cylinder head design and function
29.	Remove, check and replace gasket	2	29. Kinds of gasket materials
30.	Inspect cylinder head for cracks		
31.	Check cylinder for cracks	2	31. Methods of repairing cracked cylinders
32.	Ream ridge from top of cylinder		
33.	Hone cylinder		
34.	Remove and replace valve, valve guides, spring, retainer and retainer key	3	34. Design, functions, and arrangement of valves
35.	Check valve for warpage		
36.	Grind valve head	3	36. Proper angles of valve seat bevels
37.	Grind valve seat		
38.	Lap valve	3	38. Kinds of lapping compounds
39.	Adjust valve clearance		
40.	Remove and replace cam shaft and timing gear or chain.	3	40. Cam shaft design and function
41.	Check timing gears, chains, and cams for wear		
42.	Remove and replace cam bushings		
43.	Ream and fit new cam bushings		

Engine Lubrication and Service

	4	44.	Kinds of lubricants
	4	45.	Purposes of lubricants
	4	46.	Sources from which lubricants are derived
	4	47.	Grades of oils
	4	48.	Kinds and uses of oil additives
49.	4	49.	Lubricants for small gas engines
50.	4	50.	Causes for high oil consumption

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
51. Lubricate generator		
52. Lubricate water pump		
53. Lubricate magneto		
54. Lubricate distributor	4	55. Causes for crankcase dilution
56. Mix fuel and oil for 2 cycle engine	4	56. Correct proportion of fuel-oil mixture

Fuels, Carburetion and Service

	5	57. Types of fuels
	5	58. Sources from which fuel are derived
	5	59. Purpose and function of the carburetor
60. Trace flow of fuel through carburetor	5	60. Carburetor design
	5	61. Types of carburetors
	5	62. Types of fuel systems
63. Adjust carburetor	5	63. Meaning of fuel-air ratio
64. Diagnose and remove cause of vapor lock	5	64. Cause for vapor lock
	5	65. Cause for carburetor icing
66. Clean and adjust carburetor	5	66. Causes for poor carburetor performance
67. Remove, clean and replace fuel tank	5	67. Design and function of fuel tank
68. Repair leak in gas tank		
69. Remove, replace, and adjust float	5	69. Design and function of float
70. Adjust idle needle valve	5	70. Design and function of idle needle valve
71. Remove and clean fuel pump	5	71. Function and design of fuel pump
72. Remove and replace diaphragm		
	5	73. Design and function of butterfly valve
74. Adjust float and float needle valve	5	74. Design and function of float needle valve
75. Remove, clean and replace gas line and sediment bowl		
	5	76. Function of sediment bowl

<u>JOB TRAINING: What the Worker Should Be Able to Do</u>	<u>Assign. No.</u>	<u>RELATED INFORMATION: What the Worker Should Know</u>
<u>Starting, Lighting and Ignition</u>		
	6	77. Fundamentals of electricity and magnetism
	6	78. Meanings of terms peculiar to the field of electricity
79. Classify materials according to their conductivity	6	79. Types of materials used in electricity and their classification as to their conductivity
	7	80. Types of generators
81. Adjust generator output	7	81. Purpose and principle of generator operation
82. Remove, check, and replace generator brushes		
83. Check field winding for short*		
84. Check armature for short		
85. Lubricate generator		
86. Clean commutator		
87. Undercut mica on commutator		
88. Turn down commutator on lathe		
89. Adjust cutout relay	7	89. Principle and function of cutout relay
90. Remove, check and replace starter brushes	7	90. Design and function of starting motors
91. Clean motor commutator		
92. Turn down commutator on lathe		
93. Undercut mica on commutator		
94. Check armature and field windings for shorts		
95. Remove and replace armature bearings		
96. Remove and replace battery	7	96. Design, function and properties of storage batteries
97. Test cells for voltage	7	97. Cell voltages
98. Test electrolyte for specific gravity with hydrometer	7	98. Specific gravity of charged cell
99. Check and refill cells with water	7	99. Kinds of additives
100. Place battery on charger	7	100. Principle and function of battery charger

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
101. Clean battery and terminals	7.	102. Safe charging rates
	7	103. Polarity
	7	104. Types of charges
105. Remove and replace coil	8	105. Design and function of ignition coil
106. Check coil for short		
107. Remove and replace condenser	8	107. Design and function of ignition condensers
	8	108. Capacitance of condensers
109. Check condenser for leak	8	109. Symptoms of deficient condensers
110. Lubricate distributor	8	110. Design and function of distributor
111. Remove, replace and adjust contact points		
112. Adjust cam angle	8	113. Adjustment specifications of distributor points
114. Check wear of distributor shaft		
	8	115. Design and purpose of spark advance
116. Remove spark plug and check porcelain for cracks	8	116. Design, function and kinds of spark plugs
117. Clean plug	8	117. Causes for spark plug fouling
118. Set spark gap	8	118. Correct gap settings
119. Remove, test, and replace condenser	9	119. Types of magnetos, principles and functions
120. Remove, test, and replace coil		
121. Remove, replace and adjust breaker points		
122. Check and clean terminals		
123. Remove and replace spark advance mechanism		

LAWNMOWERS

Lawnmower Service and Repair

10.	124. Principles of lawnmowers
10	125. Function of the various parts of mowers

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
126. Inspect mower for wear	10	126. Points of greatest wear
	10	127. Types of mower blades and knives
	10	128. Types of reels
129. Disassemble and reassemble reel type mower	11	129. Types of lawnmowers
130. Disassemble and reassemble rotary mower		
131. Grind bed knife	11	131. Proper bevel for bed knives
132. Grind reel		
133. Grind rotary blade	11	133. Proper bevels for blades
134. Balance rotary blade		
135. Check rotary blade for balance	11	136. Principle and purpose of lapping process
137. Lubricate a mower	11	137. Types of lubricants used
138. Adjust reel and bed-knife	11	138. Adjustments to be made on lawnmowers
139. Align reel type mower	11	139. Possible causes for malfunctioning of lawnmowers
140. Adjust reel bearings	11	140. Remedies for malfunction
141. Adjust depth of cut of mower		
142. Straighten bent blade		

CHAIN SAWS

Chain Saw Sharpening

143. Remove and install chain		
144. Inspect chain	12	144. Reasons chains get dull
145. Clean and lubricate saw chain	12	145. Principles of chain "break in"
146. Replace links or teeth	12	146. Factors leading to drive link breakage
147. Adjust chain tension	12	147. Causes of excessive stretch
148. Select files	12	148. Recommended file sizes
149. Hand file chain clearances	12	149. Filing and grinding angles

<u>JOB TRAINING: What the Worker Should Be Able to Do</u>	<u>Assign. No.</u>	<u>RELATED INFORMATION: What the Worker Should Know</u>
150. Set up grinder	12	150. Effects of and determination of proper depth gauge settings.
151. Grind chain		

OUTBOARD MOTORS

Lower Units and Propellers

152. Inspect driveshaft housing and gear case	13	152. Principles of housing and gear case construction.
153. Install gears, shafts and shifting mechanisms	13	153. Kinds and specifications of gears and shafts
154. Inspect and replace oil and grease seals	13	154. Kinds and types of seals.
155. Lubricate lower units.	13	155. Types of lower unit lubricants and systems
156. Inspect and replace bearings	13	156. Kinds and types of bearings
157. Inspect and repair cooling systems	13	157. Kinds and types of cooling systems
158. Inspect and "clear" exhaust systems		
159. Inspect and install propellers and shear pins	13	159. Theory of propeller design
	13	160. Types and kinds of propellers
161. Clean and care for motor	13	161. Requirements for cleaning and storing
	13	162. Special considerations relative to salt water use

BICYCLES

Bicycle Steering Assembly

163. Disassemble steering mechanism	14	163. Principles of the steering mechanism
164. Assemble and adjust steering mechanism	14	164. Parts of steering assembly
	14	165. Types of steering heads
166. Lubricate steering assembly	14	166. Lubricant used for steering assembly
167. Adjust bearings	14	167. Proper adjustment of bearings
168. Straighten front fork		

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
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Saddle

169. Methods of attaching seat	14	169. Types of seat pillars
170. Adjust position of saddle	14	170. Proper height of seat adjustments
171. Remove and replace saddle	14	171. Types of saddle adjustments
172. Adjust saddle for different weight loads		

Hubs, Wheels and Drive Mechanisms

	15	173. Design and function of wheel hubs
174. Disassemble, clean and assemble front hub	15	174. Adjustments to be made on hubs
175. Disassemble, clean and assemble rear hub		
176. Adjust front hub bearings		
177. Adjust rear hub bearings		
178. Remove and replace hub sprocket		
179. Align rear hub sprocket with chain wheel		
180. Remove and replace free wheel	15	180. Design and function of free wheel
181. Lubricate hub	15	181. Type of lubricant used for hubs
182. Inspect hubs for wear and other defects	15	182. Kinds of defects to look for
	15	183. Points of greatest wear

Bottom Bracket

184. Remove and replace chain	15	184. Types of chains
185. Clean chain		
186. Adjust chain tension	15	186. Adjustments for chain
	15	187. Maximum and minimum allowable chain tension
188. Inspect chain and chain wheel for wear and other defects		
189. Lubricate chain	15	189. Lubricants used for chains

190.	Adjust length of chain	15	190.	Types of chain links
191.	Remove and replace chain wheel	15	191.	Types of chain wheels
192.	Straighten chain wheel	15	192.	Methods of manufacturing chain wheels
193.	Remove, straighten and replace crank	15	193.	Design and function of cranks
194.	Remove and replace crank pedals	15	195.	Types of pedals
196.	Adjust pedal bearings	15	196.	Adjustments to be made on pedal bearings
197.	Compute gear and sprocket sizes	15	197.	Standard gears for bicycles

Wheels

199.	Remove and replace hub	15	198.	Types of spoke design
		15	199.	Types of wheels and number of spokes used in each
200.	Respoke wheel	15	200.	Principles of tying and soldering spokes
201.	Adjust spoke tension			
202.	Straighten bent rim			
203.	Cut spoke to length			
204.	Remove and replace spoke nipple			
205.	Select proper spokes for job	15	205.	Spoke gauges

Hand Brakes

		16	206.	Types of hand and hub brakes
		16	207.	Principles of hand and hub brakes
208.	Install brake blocks	16	208.	Kinds of brake linings and brake blocks
209.	Adjust brake blocks	16	209.	Kinds of brake improvers and their uses
210.	Rivet linings to shoes			
211.	Remove and replace brake linings	16	211.	Methods of attaching linings to shoes
212.	Remove and replace brake assemblies	16	212.	Parts of hub and rim brakes

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
213. Lubricate hand brake assembly	16	213. Where to lubricate brake assembly
	16	214. Type of lubricant to use on brake assembly
215. Remove and replace brake cable	16	215. Materials from which cables are made

Hub Gears

	17	216. Types of hub gears
	17	217. Design and function of hub gear
218. Disassemble and assemble hub gears		
219. Inspect hub gear assembly for wear		
220. Install derailing gear		
221. Adjust hub gear bearings		
222. Adjust hub gear	17	222. Hub gear adjustments
223. Lubricate hub gear	17	223. Lubricants used in hub gears
224. Lubricate control cable		
225. Remove and replace hub gear control	17	225. Design and principles of hub gear controls
226. Adjust control cable		
227. Disassemble and reassemble derailing gears	17	227. Design and function of railing type gears

Coaster Brakes

229. Disassemble and assemble coaster	17.	229. Types of coaster brakes
230. Clean and lubricate coaster brakes	17.	230. Lubricants used on coaster brakes
	17	231. Principles of operation of different types of coaster brakes
232. Inspect coaster brake assembly for wear and other defects	17	232. Points of wear on brake assembly
234. Adjust assembly	17	233. Causes for poor braking

JOB TRAINING: What the Worker Should Be Able to Do	Assign. No.	RELATED INFORMATION: What the Worker Should Know
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KEYS

Duplication of Keys

235. Select key blanks	18	235. Types of keys and their uses
	18	236. Shapes of key heads
	18	237. Parts of keys
	18	238. Materials from which keys are made
	18	239. Location of numbers on key blanks
240. Identify grooves by sight	18	240. Kinds and shapes of grooves employed in key blanks
241. Duplicate corrugated keys	18	241. Primary parts of key duplicating machine
	18	242. Uses of special pins
243. Duplicate one and two-sided keys		
244. Shorten long key blanks		
245. Trace a key		
246. Order unstocked key blanks		

BUSINESS MANAGEMENT

Hazards

	19	247. Types and classes of fires
248. Determine appropriate extinguisher for different classes of fires	19	248. Types of fire extinguishers
	19	249. Kinds of fire hazards
	19	250. Conditions under which business owner is liable for injuries
	19	251. Types of hazards usually found in shops
	19	252. Importance of liability insurance
	19	253. Nature and requirements of disability compensation law
	19	254. Procedure for handling injuries occurring in the shop

<u>JOB PRICING: What the Worker Should Be Able to Do</u>	<u>Assign. No.</u>	<u>RELATED INFORMATION: What the Worker Should Know</u>
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Job Pricing

255. Compute minimum hourly rate	19	255. Ways of computing job costs
256. Estimate labor cost for a job	19	256. Factors affecting production costs
257. Estimate parts cost for a job		
258. Compute estimated operating cost for business establishment	19	259. Advantages and disadvantages of flat rate pricing
	19	260. Advantages and disadvantages of pricing on hourly basis
	19	261. Conventional charges for general repair work
	19	262. Conventional charges for key duplication

Job Management

263. Make a job ticket	19	263. Types and uses of job tickets
	19	264. Characteristics of job tickets
	19	265. Sales agreements and job orders
266. Receive incoming job	19	266. Ways of recording incoming job
267. Record incoming job		
268. Estimate time required to do a job	19	268. Importance of time estimates
269. Make material list	19	269. Importance of keeping material lists
	19	270. Effects of free service and unproductive time on profits
	19	271. How to determine amount of free time given
	19	272. Factors affecting profits

Assignment
Sheet No. 1

Covering Units
1-9

THE SMALL GAS ENGINE

In our rapidly changing society, new devices are constantly being developed to make our work easier and our recreation more enjoyable. Those devices which require inanimate power are making increasing use of the small gasoline engine. This trend may be witnessed by the tremendous growth in sales of power mowers, outboard motors, chain saws, and many other similar devices.

Before one can enter into a study of the components of the small gas engine he must first acquaint himself with the common terms that are used in discussing engines and their operation. Secondly, a background knowledge pertaining to the operating principles of engines is necessary if the business is to be approached intelligently and with a degree of success.

It is the purpose of this assignment to familiarize you with the types of engine cylinder and valve arrangements, methods of measuring power and efficiency, and some essential principles of engine operation which will provide you with an adequate background for further study and understanding of gasoline engine components.

Assignment:

1. Read the reference listed below.
2. Make a list of the different small gas engines you see in operation in one day. Think of other common daily uses of the small gas engine.
3. Answer the questions below and turn in this assignment by _____.

Reference:

- A. Purvis, All About Small Gas Engines, pp. 9-34.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. A gas engine is also known as an internal combustion engine.
- T F 2. Two cylinder engines are known as two-cycle engines and engines with four cylinders are known as four-cycle engines.
- T F 3. Air cooled engines have fins attached to the head to dissipate excess heat.
- T F 4. Each cylinder of a four-cycle engine produces a power stroke for each revolution of the crankshaft.

- T F 5. The fuel mixture of a two stroke engine is drawn through the crankcase.
- T F 6. Each cylinder of a two stroke engine produces a power stroke for each revolution of the crankshaft.
- T F 7. Poppet valves are not generally used on two stroke engines.
- T F 8. The I-Head engine is more commonly known as a valve-in-head engine.
- T F 9. Small one-or two-cylinder engines lend themselves well to use on lawnmowers because power output for a given engine size is about four times as high as it was 30 years ago.
- T F 10. The power of an engine is determined by the number of cylinders.
- T F 11. Rated horse power is a very accurate means of determining the real power of an engine.
- T F 12. A two cylinder engine with a bore of 3 inches and a stroke of 7 inches will have the same "rated horsepower" as the same engine with a 5 inch stroke.
- T F 13. The piston displacement of an engine is equal to the swept volume of one cylinder multiplied by the number of cylinders and gives some indication as to the potential power of the engine.
- T F 14. An engine with the ability to lift a weight of 100 lbs. one foot in one minute would have the same horsepower rating as an engine that could lift a 1 lb. weight one hundred feet in one minute.
- T F 15. Indicated horsepower is a mechanic's term denoting the developed horsepower of an engine.
- T F 16. The compression pressure of an engine tells a mechanic a great deal about the condition of an engine.
- T F 17. The measure of compression pressure is taken when the piston has reached top dead center on its compression stroke.
- T F 18. The torque of an engine is dependent entirely upon the speed of the engine.
- T F 19. The farther a given weight is located from the center of a shaft, the less the foot-pounds of torque required to lift the weight.

- T F 20. An engine with a cylinder volume of 300 cubic inches at the bottom of its stroke and a volume of 50 cubic inches at the top of its stroke would have a compression ratio of 6 to 1.
- T F 21. There has been a tendency to increase compression ratios of engines during the past thirty years.
- T F 22. After reading the assigned reference, it can be assumed that high compression engines tend to run hotter than low compression engines, making heat dissipation a distinct problem of high compression.
- T F 23. A two-cylinder, 4 cycle engine, fires on one cylinder for each revolution of the crankshaft.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. The two principle types of cooling systems are _____ and _____.
2. The quantity of gas that enters the cylinder of an engine determines its _____ efficiency at that speed.
3. Superchargers are used to _____ the volumetric efficiency of an engine.
4. To grind down the cylinder head of an engine would _____ its compression ratio.
5. Building up the height of a piston will _____ the ~~compression~~ ratio of an engine.
6. Replacing a head gasket with a thicker one will _____ the compression ratio of an engine.
7. An accompanying evil of the high compression ratio is _____.
8. The firing orders of 4-cylinder engines are _____, _____, _____, _____ and _____, _____, _____, _____.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Four kinds of cylinder arrangements are:

- | | |
|-----------|-----------|
| (A) _____ | (C) _____ |
| (B) _____ | (D) _____ |

2. Four general engine designs as determined by valve arrangements are:

(A) _____ (C) _____
(B) _____ (D) _____

3. Two instruments for measuring the developed horsepower of an engine are:

(A) _____ (B) _____

Assignment
Sheet No. 2

Covering Units
10, 13, 15, 22,
27-29, 31

PISTON, ROD AND CRANKSHAFT ASSEMBLY

The piston, rod and crankshaft assembly is primarily responsible for converting the energy of expanding gases into reciprocating motion and then into rotary motion. As a general rule, if one of these units becomes inoperative a major overhaul may be necessary. Mere adjustments are generally not sufficient to correct malfunctioning of these parts. A large per cent of the overhaul jobs done will be concerned with at least one of these units.

As a small engine repairman, you will be undertaking these repair jobs. Because of the critical tolerances that must be maintained, your job becomes one of extreme accuracy and precision.

In this assignment you will have the opportunity to study the function of pistons, rods, and crankshaft and their relationship to each other.

Assignment:

1. Read the reference listed below.
2. Answer the questions below and turn in this assignment by _____.

Reference:

- A. Purvis, All About Small Gas Engines, pp. 30-79, 118-121, 129, 256-258.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. V-type engines often connect two rods to one throw.
- T F 2. The purpose of the crankshaft is to change the reciprocating motion of the piston to a rotary motion.
- T F 3. The bearings in which the crankshaft revolves are called rod bearings.
- T F 4. The part of the crankshaft which fits into its supporting bearings is called the pin.
- T F 5. All engines have a main bearing for each cylinder.

- T F 6. The crankshaft is made with extreme accuracy and is generally forged from one piece of steel.
- T F 7. The bearing journals of a crankshaft operate independently and do not have to be aligned with each other.
- T F 8. The primary purpose of the flywheel is to help the engine idle smoothly.
- T F 9. As a general rule, high speed engines have lighter flywheels than low speed engines.
- T F 10. A critical speed is one at which even the most accurately balanced engines will vibrate.
- T F 11. Due to various factors, bearings seldom wear equally.
- T F 12. Integral or poured bearings are made of lead.
- T F 13. The insert type bearing cannot be adjusted; therefore, it should be purchased in the exact size needed.
- T F 14. Bearings in a splash oil system require fitting to a closer tolerance than bearings of a pressure oil system.
- T F 15. When the diametral clearance of a rod or main bearing exceeds .005 inch, the bearing should be replaced or adjusted.
- T F 16. If a crankshaft journal is worn, the insert should be removed and replaced with an oversize insert.
- T F 17. The rod cap should never be drawn tight enough to prevent the insert or shell from rotating with the crankshaft.
- T F 18. Bearing crush is highly undesirable and should always be prevented when installing inserts.
- T F 19. The integral type main bearing can be adjusted either by the use of shims or by filing the bearing cap.
- T F 20. When fitting rod bearings, care should be taken to remove all side clearance to prevent wasted side motion of the rod.
- T F 21. Newly fitted rod bearings should bind until the engine is broken in.
- T F 22. Misalignment of a rod bearing may cause a tight, newly overhauled engine to knock.
- T F 23. Because piston rings serve as a seal between the piston and cylinder wall, it is not necessary for the piston to be well fitted.

- T F 24. Cast iron pistons are almost universally used in engines because they expand at the same rate as the block.
- T F 25. Aluminum alloy pistons never have split skirts because expansion is not a problem.
- T F 26. A six inch diameter cast iron piston should be approximately .006 inch smaller than the cylinder.
- T F 27. The type of piston and its surface treatment will determine to some degree its clearance requirement, which is usually determined and recommended by the manufacturer.
- T F 28. The best way to check the clearance of a piston is to turn the crankshaft until the piston reaches the top of its stroke then move piston from side to side with the hand.
- T F 29. A slightly worn piston skirt can be "resized" or made larger by the use of steel piston expanders; but if they are used they must be used in all pistons whether or not they need to be expanded.
- T F 30. Over heating can cause piston rings to lose their effectiveness.
- T F 31. Rings are made so they are fixed rigidly to the grooves of the piston.
- T F 32. Although blow-by can not be completely eliminated, it can be minimized by staggering the positions of ring gaps when the rings are installed.
- T F 33. If the compression of an engine checks out to be good, the possibility of its being an "oil pumper" is eliminated.
- T F 34. It is necessary to allow more gap clearance for top rings than for lower rings.
- T F 35. Exact control of side spacing is not important in piston rings as long as the ring is free to move in the groove.
- T F 36. Ring gaps should always be aligned on one side of the piston before inserting it into cylinder.
- T F 37. When worn, piston pins should be removed and turned down on lathe and replaced in undersized bushings.
- T F 38. A greater tolerance is allowed in fitting piston pins than in fitting rod bearings.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. A rod knock can be detected (A) at idle speeds; (B) at low speeds; (C) at both high and low speeds; (D) only when the engine is cold.
- _____ 2. A loose flywheel can be detected by (A) shorting out one plug; (B) turning ignition off and then on; (C) running at high speeds; (D) putting engine under heavy load.
- _____ 3. The main difference in a rod knock and a main bearing knock is (A) shorting out plug on cylinder will affect sound of rod knock only; (B) shorting out plug on cylinder will affect sound of main bearing only; (C) main bearing knock is heavier than rod knock; (D) rod knock is heavier than main bearing knock.
- _____ 4. A piston slap may be suspected if (A) the knock decreases when engine warms up; (B) there is a heavy knock at idle speed; (C) there is a heavy knock at high speeds; (D) knock is heard twice every revolution of crankshaft.
- _____ 5. A loose piston pin is often characterized by (A) heavy knock; (B) loudest noise at high speeds; (C) diminishing knock when engine is warm; (D) a double knock each revolution of crankshaft.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. Two causes of engine vibration are _____ force and _____ forces.
2. Side clearance of a connecting rod bearing should range between two extremes which are _____ and _____ inch.
3. Two types of piston rings are _____ and _____ rings.
4. The top surface of a piston is called _____.
5. Piston rings exert a pressure of about _____ to _____ pounds against the cylinder wall.
6. The top ring of a piston is a _____ ring.
7. The lower ring of a piston is an _____ ring.

8. Generally, in the absence of manufacturers' instructions, ring gap clearance should be _____ inch per inch of piston diameter for top rings, and _____ inch per inch of piston diameter for bottom rings.
9. A _____, grinder, or _____ may be used to bring new pin bushings to correct size.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Five types of pistons are:

(A) _____	(D) _____
(B) _____	(E) _____
(C) _____	

2. Three types of piston pin locking systems are:

(A) _____
(B) _____
(C) _____

VALVE, CAM AND TIMING ASSEMBLY

By the use of valves, fuel is admitted to cylinders to be burned and then expelled in the form of exhaust gasses. Valves operate under extreme heat, making it very difficult to maintain correct timing, thus affecting the volume of gas admitted to cylinders each intake stroke. When valves are improperly timed or adjusted, grave limitations are placed upon the performance of an engine.

Valves are, therefore, a very common cause of engine trouble. Adjustments are often necessary, and accuracy in making such adjustments is important. A mechanic must know and understand a great deal about the design and function of the valve and cam assembly to know that proper valve adjustment is more than quieting a noisy valve. Improperly functioning valves produce many symptoms and you must know how to detect and remedy them.

In this assignment you will have the opportunity to study the valve and cam assembly and to see the contribution it makes to the efficiency of an engine.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- A. Purvis, All About Small Gas Engines, pp. 34-38, 51-53, 60-62, 80-95, 116-121, 124-131, 236-237.
- B. Lawn-Boy Service Manual, pp. 1-2, 43-45.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. An exhaust valve runs much hotter than an intake valve.
- T F 2. Exhaust and intake valves are identical in design, size, and materials from which they are made.
- T F 3. A push rod is used to close exhaust valves.
- T F 4. The camshaft is used to operate pushrods which in turn actuate valves.

- T F 5. The exhaust and intake valves are never open at the same time.
- T F 6. A camshaft contains a lobe for each valve in the engine.
- T F 7. The camshaft of a four cycle engine turns at one-half the crankshaft speed.
- T F 8. A worn cam cannot affect the operation of an engine as long as it opens the valve enough to allow the gasses to pass through.
- T F 9. Cams are designed for the most efficient performance of an engine.
- T F 10. When a cam lobe becomes worn, it should be removed and replaced.
- T F 11. Camshaft bearings are usually of the roller type.
- T F 12. Bushings are specified by both inside and outside diameters.
- T F 13. The easiest way to install bushings is to drive them into place with a hammer, taking care not to bend or otherwise deface them.
- T F 14. Small two cycle engines may often use roller type camshaft bearings.
- T F 15. Valves are cooled by circulating water through them.
- T F 16. A valve seat may be ground into the engine block, or in some engines the valve seat is a removable insert.
- T F 17. A valve which does not seat properly will run hotter than a properly operating valve.
- T F 18. Valves may tend to seat improperly if cylinder head bolts are not evenly tightened.
- T F 19. If a valve seats properly when cool, the mechanic can be sure that it will seat properly in operation.
- T F 20. Valve inserts are often "packed in ice" prior to installation so that they may be readily installed into the hole in the block.
- T F 21. An exhaust valve is more likely to become "sticky" due to carbon deposits on the stem than are intake valves.
- T F 22. Except for the excessive noise they tend to produce, worn valve guides have little effect upon the performance of an engine.

- T F 23. Because they tend to run hotter, intake valves require more clearance in their guides than exhaust valves.
- T F 24. A valve spring can be assumed to be okay if it measures the correct length when not compressed.
- T F 25. Valves are often permitted to rotate in position to prevent carbon deposits from forming and to lengthen the expected life of the valve.
- T F 26. As long as a timing gear or chain has not slipped out of its proper location, the engine can be assumed to be in perfect timing.
- T F 27. Valve clearance adjustments cannot be made on some types of valves except by grinding the end of the valve stem.
- T F 28. A timing gear knock is not affected by shorting out a plug or by running engine at high or low speeds.
- T F 29. Valves seldom cause noise in an engine.
- T F 30. It is considered good practice to use compressed air when cleaning reed valves.
- T F 31. A V-block and dial indicator may be used when checking a camshaft for bend.
- T F 32. The reed valves of the two cycle engine serve the same purpose as the intake valves in a four cycle engine.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

- Two kinds of valves are _____ and _____.
- Three parts of the cam are the _____, _____, and _____.
- Some camshafts are _____ driven while others are _____ driven.
- The bevel of a valve face should be ground at an angle of _____ degrees with the stem.
- A valve should be discarded if it is worn, bent, pitted or scored more than _____ inch.
- Valve clearance or tappet clearance is checked with a _____ gauge.

7. The type of valve most commonly used in the four cycle engine is the _____ valve.
8. The best method for reconditioning valves is _____.
9. The _____ valve is closed when the fuel mixture is compressed within the crankcase.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. The parts of a poppet valve assembly are:

(A) _____	(D) _____
(B) _____	(E) _____
(C) _____	(F) _____

2. Three main causes for broken valves are:

(A) _____	(C) _____
(B) _____	

3. Factors contributing to excessive heat in valves are:

(A) _____	(F) _____
(B) _____	(G) _____
(C) _____	(H) _____
(D) _____	(I) _____
(E) _____	

Assignment
Sheet No. 4

Covering Units
44-50, 55, 56

ENGINE LUBRICATION AND SERVICE

Lubrication is big business. Billions of barrels of crude oil, from which millions of gallons of oil and other lubricants are refined, are pumped from the earth each year. All of these products are then used in the attempt to control or reduce frictions.

The control of friction has been one of the greatest problems of engineers since the invention of machines. Many of the jobs mechanics have to do are primarily brought about by the use of improper lubricants and lubricating methods.

In this assignment you will have the opportunity to study about the kinds and purposes of lubricants and their influence upon the life and efficiency of an engine.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- A. Purvis, All About Small Gas Engines, pp. 97-103, 115-116.
- B. Lawn-Boy Service Manual, pp. 1, 2, 83, 84.

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. If the proper lubricant is used, friction can be completely eliminated.
- T F 2. Most lubricants are made from crude oil.
- T F 3. Many commercial lubricants are compounded with animal fats and vegetable oils.
- T F 4. The lubricant serves as a coolant.
- T F 5. Excessive friction can generate sufficient heat to ruin a working part.
- T F 6. The lack of adequate lubrication will probably cause a loss of power.

- T F 7. Lubricating oil in the engine helps to prevent a compression leak by acting as a seal between the cylinder wall, ring and piston.
- T F 8. A valuable function of oil is that of washing abrasive particles out of the working parts.
- T F 9. Engine oil is normally thicker in warm weather than in cold weather.
- T F 10. In effect, engine oil works on the principle of several layers of ball bearings of very small size.
- T F 11. A heavier oil should be used in the winter than in the summer.
- T F 12. SAE is the best quality of oil available.
- T F 13. SAE 10 is thicker than SAE 30.
- T F 14. An advantage in using W oil is that it does not thicken as rapidly as other oils.
- T F 15. An oil may have both the W and SAE designation.
- T F 16. When a manufacturer recommends a particular weight of oil, it is generally safe to use lighter weights because the closely fitted parts might not be lubricated sufficiently.
- T F 17. When oil is present in a bearing the working parts are held apart, thus preventing any metal-to-metal contact.
- T F 18. Oil vapor is an important means of lubricating the two cycle engine.
- T F 19. Engines may be lubricated by the splash system, by the pressure system, or by a combination of the two.
- T F 20. An oil additive is used to thin out crank case oil.
- T F 21. Choking an engine may cause crankcase dilution.
- T F 22. Crankcase dilution does not seriously damage the lubricating ability of the oil.
- T F 23. Most of the engine wear takes place during the first few minutes after an engine is started.
- T F 24. A slow warmup period to start lubrication will add life to the engine.
- T F 25. Crankcase dilution is caused by unburned gasoline washing by piston and rings and into the crankcase.

- T F 26. Fuel, for a two cycle engine, is a vaporized mixture of gas and oil.
- T F 27. When storing an engine for an extended period place a teaspoon of oil into the cylinder through the spark plug hole.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. Three types of oil additives are _____, _____ and _____.
2. Lubricants are used to overcome _____.
3. Friction produces _____.
4. Lubricants are derived from four sources which are _____, _____, _____, and _____.
5. The _____ cycle engine is equipped with an oil reservoir.
6. Crankcase dilution means that the oil has been diluted with _____.
7. Multiple-viscosity _____ should not be used for two cycle engine fuel.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. Dispersive oil additives are used to (A) thin oil; (B) replace lost oil; (C) prevent sludge from forming; (D) keep oil from evaporating.
- _____ 2. Most engine wear takes place (A) in hot weather; (B) while warming up; (C) while running at operating speed; (D) while setting idle.
- _____ 3. SAE 40 oil is considered (A) heavy; (B) light; (C) medium; (D) no such grade.
- _____ 4. The two cycle engine is likely to be lubricated with (A) an oil pump; (B) splash system; (C) oil can; (D) fuel and oil vapor.
- _____ 5. Lubricants serve to (A) eliminate friction; (B) keep plugs clean; (C) prevent carbon from forming on piston; (D) hold moving parts apart.

FUELS, CARBURETION AND SERVICE

An engine without power is useless. Every wheel that turns must have a source of power to propel it. There are many fuels used to operate internal combustion engines, but gasoline is probably most commonly used.

Gasoline is not power; it is a source of power. It is only when gasoline is vaporized, mixed with air in the right proportions, and burned under controlled conditions that usable power can be derived from it.

In this assignment you will have the opportunity to learn something about the characteristics of gasoline and the means of controlling it to produce power.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- A. Purvis, All About Small Gas Engines, pp. 9, 43, 137-151.
- B. Lawn-Boy Service Manual, pp. 2, 3, 9-25.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. Gasoline has a natural orange or red color.
- T F 2. Gasoline is relatively light in weight, being somewhat lighter than water.
- T F 3. Gasoline is produced from crude petroleum.
- T F 4. The color in gasoline is produced by adding dye.
- T F 5. Little improvement has been made in the quality of gasoline during the last 30 years.
- T F 6. The carburetor injects into the engine a stream of gasoline which is mixed with air after it enters the combustion chamber.

- T F 7. Gasoline vaporized more easily in the early days of the gasoline engine than it does at the present time.
- T F 8. Some of the first carburetors contained wicks over which air was drawn into the cylinder.
- T F 9. The float and needle valve serve to keep the gasoline level approximately constant in the carburetor.
- T F 10. A richer fuel mixture is needed to run an engine under heavy load or at idle speed than to run it at a moderate speed and load.
- T F 11. A ratio of one part of gasoline to sixteen parts of air is considered a lean mixture.
- T F 12. Choking an engine will reduce the fuel-air ratio, making the mixture richer.
- T F 13. The idle jet is made necessary because the suction in the carburetor is drastically reduced when the engine is idling.
- T F 14. Fuel is drawn through the idle jet at both the high speeds and while idling.
- T F 15. A carburetor may contain more than one venturi.
- T F 16. The down-draft carburetor was the first type to come into general use.
- T F 17. The main disadvantage to the up-draft carburetor is that it will not supply the engine enough fuel at high speeds.
- T F 18. The side-draft carburetor has an advantage over the other types because one right angle turn is avoided which allows fuel to flow more freely through the carburetor.
- T F 19. The carburetor cannot be satisfactorily adjusted until the engine is heated up to operating temperature.
- T F 20. All carburetors have a multiplicity of adjustments which must be adjusted correctly if the highest type of performance is to be expected.
- T F 21. The carburetor discharges its fuel-air mixture through the reed valve of a two cycle engine.
- T F 22. A choke is used to restrict the flow of gasoline to the engine, thus assisting the "shut-off" procedure of the engine.
- T F 23. The needle adjustments of a carburetor should be made tight in order to prevent fuel leakage.

- T F 24. Engine scorching is often caused by faulty carburetion.
- T F 25. A governor is a device which automatically increases engine power output during periods of additional load or decreases power during lightened loads.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. If the carburetor is flooding it is likely that the _____ or _____ valve is stuck.
2. Carburetor icing is most likely to take place when the temperature is between _____ and _____ degrees F.
3. Carburetor icing is more likely to occur when the humidity is _____ to _____ per cent.
4. Icing will be most noticeable when the engine is running at _____ speed.
5. The condition created by the vaporization of gasoline in a gas line is known as _____.
6. The restriction in the air tube of the carburetor is known as the _____.
7. Three of the more common names for detonation are _____, _____, and _____.
8. The term used to indicate the tendency of gasoline to resist detonation is _____.
9. The device used to supply the appropriate fuel-air ratio to the engine is known as the _____.
10. The rate of flow of _____ through the carburetor between idling speed and full load, changes in ratio of more than 100 to 1.
11. Three types of carburetors are _____, _____, and _____.
12. In a carburetor operating on the air bleed principal, the main jet controls the fuel mixture during the range from _____ to about _____ throttle opening.
13. The small pump that lifts fuel directly into the carburetor throat is called a _____.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. The carburetor venturi causes the velocity of the air passing through it to be (A) lowered; (B) unchanged; (C) increased; (D) rippled.
- _____ 2. Vapor lock may occur in the (A) fuel pump; (B) gas tank; (C) manifold; (D) combustion chamber.
- _____ 3. Before adjusting the carburetor one should check the (A) cylinder compression; (B) oil level; (C) battery; (D) humidity.
- _____ 4. The up-draft carburetor is inefficient at low speeds because it (A) uses too much gas; (B) requires flow contrary to gravity; (C) has no float needle valve; (D) has tendency to flood engine.

PRINCIPLES OF THE ELECTRICAL SYSTEM

This is an age of electricity and we are greatly dependent upon it as a source of power. Not only do we use electrical power to light our homes and businesses, but we rely upon it to run motors and engines as well. The internal combustion engine has been able to develop only due to an according development of its electrical components. Without a knowledge and understanding of certain basic electrical principles, it would be impossible to intelligently service the electrical system of an engine.

When changes and improvements appear on the market, the repairman generally knows nothing about the technical aspects of these changes, but if his background in electricity is sufficient, he will be able to adapt quickly by reading the instructions and specifications accompanying the product. This implies that he must be familiar with electrical terms pertaining to the trade and with the principles upon which the item operates.

In this assignment you will have the opportunity to study the basic principles of electricity and magnetism, and to perform a few basic experiments involving these principles.

Assignment:

1. Read the reference listed below.
2. Place a sheet of paper over a bar or horseshoe magnet and lightly sprinkle iron filings over the sheet. Sketch on a piece of paper what you see and show to your instructor.
3. Place a magnetic compass near a wire and determine (1) if current is flowing, and (2) what direction the current is flowing.
4. Answer the questions below and turn in this assignment by _____.

Reference:

- A. Purvis, All About Small Gas Engines, pp. 152-163.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. A mechanic can service an engine without an understanding of the principles of electricity.

- T F 2. A material which permits the flow of electrons through it is called an insulator.
- T F 3. Current will not flow without voltage.
- T F 4. The ability of a material to resist the flow of electricity is called amperage.
- T F 5. A poor ground may prevent a circuit from being completed, thus causing an open circuit.
- T F 6. Voltage, in an electrical circuit, is often compared to pressure in a water system.
- T F 7. Amperage is a measure of the flow of electrons.
- T F 8. The ohm is a measure of electric power.
- T F 9. In any given circuit, there will always be a constant relationship between the voltage, amperage, and resistance which can be determined by the application of Ohm's law.
- T F 10. If the voltage is known, the resistance and amperage of a circuit can be computed by the use of Ohm's law.
- T F 11. A switch must always be connected in series with the unit it is designed to control.
- T F 12. The units in a parallel circuit operate more or less independent of each other.
- T F 13. An unmagnetized piece of steel can be magnetized by rubbing it against a magnet.
- T F 14. It is a common law of magnetism that like poles attract each other and unlike poles repel each other.
- T F 15. A magnetic field can be set up by passing current through a conductor.
- T F 16. There are many materials which cannot be magnetized.
- T F 17. Magnetism might simply be defined as an alignment of the polarity of the molecules of a substance.
- T F 18. Copper, aluminum, and brass are three of the most commonly used alloys in producing permanent magnets.
- T F 19. Because the solenoid has a movable core, it can be used for several purposes such as to open and close switches.
- T F 20. When current is passed through the coil of a solenoid, the movable core is drawn to the center of the coil.

- T F 21. In electricity, power is measured in volts.
- T F 22. When checking voltage and amperage in a circuit, it is necessary for one to know whether to connect the meter in series or parallel.
- T F 23. Power is a term used to show the amount of work done in a given length of time.
- T F 24. Scientists have always agreed that the electron theory best explains the nature of electricity.
- T F 25. The experiment you made with the magnet and iron filings demonstrated the existence of the magnetic lines of force and the patterns they create.
- T F 26. The experiment also showed that magnetic lines of force often cross indiscriminately as they travel from one pole to the other.
- T F 27. In experiment number 2, the north end of the compass needle was drawn toward the wire even though no current was flowing, indicating that copper has the ability to retain magnetism.
- T F 28. In experiment number 2, the compass needle was drawn parallel to the wire through which current was flowing.
- T F 29. The strength of the magnetic field about a coil is determined by the size of the wire in the coil.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. Materials which permit the flow of electricity through them are known as (A) magnets; (B) conductors; (C) molecules; (D) insulators.
- _____ 2. If a magnet is cut in half, the two cut ends will be (A) north poles; (B) south poles; (C) a north and a south pole; (D) neither north or south poles.
- _____ 3. In cases where the direction of current is not known, the direction of magnetic lines of force can be determined best by (A) magnetic compass; (B) right hand rule; (C) left hand rule; (D) direction of winding.
- _____ 4. Soft iron is generally used for electromagnet cores because it (A) will not retain magnetism; (B) will hold magnetism; (C) is easy to bend; (D) is cheap.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. The unit of measurement of e.m.f. (electromotive force) is the _____.
2. The three basic units of electrical measurement are _____, _____ and _____.
3. The three general types of circuits are the _____, _____, and _____.
4. The electrical unit used for measuring work is the _____.
5. The watt is the electrical unit of _____.
6. The two poles of a magnet are the _____ pole and the _____ pole.
7. Two types of magnets are _____ magnets and _____ magnets.
8. The most magnetic substances known to man are _____, _____, and _____.

Assignment
Sheet No. 7

Covering Units
80, 81, 89, 90,
96-100, 102-104

GENERATORS, STARTERS AND BATTERIES

Generators, starters and batteries contribute a great deal more to the performance of an engine than we generally think. These items usually become inoperative at seemingly the most inopportune times. When they fail to operate, need for repair becomes an emergency. Most of the jobs mechanics have to do are those of an emergency nature rather than the general service or overhaul.

In this assignment the student will have the opportunity to study the principles of the starter, generator, and battery and to learn to appreciate the importance of their function in the operation of the engine.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- A. Purvis, All About Small Gas Engines, pp. 162-181, 210-221, 261.
- B. Lawn-Boy Service Manual, pp. 3-5, 7-8, 26-40.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. A coil of wire connected to a complete circuit will have current induced into it if the coil is passed through a magnetic field.
- T F 2. Copper wire is seldom used to wind armatures because copper is soft and not very durable.
- T F 3. If a current-carrying conductor is placed in a magnetic field, the magnetic lines of force will be deflected around the conductor rather than pass through it.
- T F 4. When a current carrying conductor is placed in a magnetic field, the conductor will have a tendency to rotate.
- T F 5. The generator using a collector ring will produce only alternating current.

- T F 6. The generator using an armature will produce both alternating and direct current.
- T F 7. The direct current produced by a generator is identical to that produced by the battery.
- T F 8. All the coils of an armature are connected to each of the commutator segments.
- T F 9. The magnetic field of the generator is produced by permanent magnets.
- T F 10. A shunt wound generator is one in which the field winding is connected in parallel with the armature winding.
- T F 11. The voltage output of a generator may be increased by increasing the strength of the field or by increasing the speed of the armature.
- T F 12. The current output of a series wound generator is apt to be more variable than the shunt wound generator.
- T F 13. The current output of a compound wound generator decreases as the speed of the armature increases.
- T F 14. The output of a third brush type generator can be regulated simply by changing the position of the third brush.
- T F 15. The number of magnetic lines of force in a generator are determined by the voltage and number of turns of wire in the armature.
- T F 16. The third brush generator has an extremely high output at very high or very low speeds.
- T F 17. A voltage regulator is used to control the rate of charge of batteries at different speeds and under different battery conditions.
- T F 18. A "standard duty" generator is one which has a high output.
- T F 19. The interpole of a generator is used not only to neutralize the magnetic effect of the armature coils, but also to cut down the arcing between the commutator and brushes.
- T F 20. A bucking field instead of an interpole can be used to neutralize the magnetic effect on the armature coils.
- T F 21. The generator or starter should never be lubricated because of fire hazards.
- T F 22. Since new brushes come from the factory ready made, it is not necessary to fit them to the commutator.

- T F 23. The cut-out relay operates on the electromagnet principle by closing when the output of the generator becomes sufficient to magnetize the core and close the circuit between the generator and battery.
- T F 24. To check the voltage at which the cut-out relay closes, one voltmeter lead should be connected to the "Gen" terminal and the other voltmeter lead should be connected to the "Bat" terminal.
- T F 25. All starter motors are of shunt wound type to insure constant power and quick starting.
- T F 26. The magnetic laws of repulsion and attraction determine the principle upon which the starting motor works.
- T F 27. If a conductor through which current is flowing is placed inside a magnetic field, the interaction of the two opposing magnetic fields will tend to rotate the conductor.
- T F 28. Rules for servicing generators can in most instances be applied to servicing starter motors.
- T F 29. The standard voltage of each cell of a storage battery is approximately 2 volts.
- T F 30. The cells of a battery are connected in parallel to increase the voltage output.
- T F 31. The proportion of sulphuric acid to water in the electrolyte may be checked by its specific gravity as determined by a hydrometer.
- T F 32. A storage battery is not in reality a store of electricity but is only a means of converting chemical energy into electrical energy.
- T F 33. A battery is rated by the length of time it will maintain 5.25 volts under a discharge load of 1/20 of its amp hour rating.
- T F 34. The temperature of the electrolyte has a direct bearing on its specific gravity when measured by a hydrometer.
- T F 35. When several batteries are to be charged at one time, they should be connected in parallel.
- T F 36. Three days is the maximum length of time it is safe to charge a battery after periodic hydrometer readings fail to show an increase in specific gravity.
- T F 37. A spark plug will not fire if the porcelain is cracked or broken.

- T F 38. A "no spark" ignition trouble may often be caused by a cracked lead wire.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. The two main electrical parts of the generator are the _____ and _____.
2. The output of a generator is determined by the number of _____ of force cut by the _____ coils.
3. A dirty commutator should be cleaned only with No. _____ sandpaper and never with emery paper.
4. The mica of a commutator should be undercut _____ inch below the surface of the commutator bars.
5. Brushes should be removed and replaced when they are worn to approximately _____ their original length.
6. Too much brush spring tension is not desirable because it will cause rapid _____ of the _____ and _____.
7. The _____ is the space between the armature and core of a cutout relay when the points are closed.
8. The specific gravity of a fully charged battery is approximately _____.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. To increase the output of a third brush generator, the brush should be (A) removed; (B) moved in direction of armature rotation; (C) moved opposite direction of armature rotation; (D) brush cannot be moved.
- _____ 2. The commutator should be removed and turned down on a lathe (A) when dirty; (B) every six or eight months; (C) when rough and pitted; (D) when the undercut disappears.
- _____ 3. The proper way to clean a generator is to (A) blow out with air; (B) wash with gasoline; (C) wash with water; (D) stand on end and hit with hammer.

4. A blue brush spring indicates that (A) the spring is new; (B) spring is burned and should probably be replaced; (C) spring is still okay; (D) the spring is not original equipment.
5. A generator is probably generating excessive current if (A) commutator is dirty; (B) brushes are worn; (C) mica needs undercutting; (D) pieces of solder can be seen on generator cover band.
6. The cut-out relay is placed in the circuit to (A) prevent over charging of battery; (B) prevent brushes from arcing; (C) keep battery from discharging through generator; (D) increase output of generators.
7. The starting motor may be seriously damaged by heat if run longer than (A) 30 seconds; (B) 60 seconds; (C) 5 seconds; (D) 2 minutes.

Assignment
Sheet No. 8

Covering Units
105, 107-110,
113, 115-118

COMPONENTS OF THE ELECTRICAL DISTRIBUTION SYSTEM

The electrical distribution system of an engine probably contributes as much to the efficiency of its performance as any other one thing. Electrical systems have become so complex in many lines of repair, that the general repairman no longer attempts to repair them. It is never-the-less important for all mechanics to have some knowledge of electricity, because the overall performance of an engine is always dependent upon the performance of its electrical system.

In most instances the general mechanic, such as you are training to be, will be responsible for his own electrical repairs. A defective electrical component can cause considerable trouble, especially for the inexperienced mechanic. With a sufficient background in electrical fundamentals, and with a knowledge of the principles and functions of the parts of the electrical distribution system, it should be easy for you to diagnose and service most of the electrical troubles.

In this assignment you will have the opportunity to study the components of the electrical distribution system and to see how they contribute to performance of the engine.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- A. Purvis, All About Small Gas Engines, pp. 182-210.
- B. Lawn-Boy Service Manual, pp. 3-6, 26-31.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. It is the purpose of the condenser to increase voltage.
- T F 2. A 6-volt battery will not produce a spark hot enough to jump the gap of a spark plug.
- T F 3. The ignition coil raises the voltage of the battery from 6 to 20,000 volts.

- T F 4. Ignition coils operate on the transformer principle.
- T F 5. Secondary windings of ignition coils always have more turns than primary windings.
- T F 6. The high tension voltage of ignition coils is produced in the secondary winding.
- T F 7. Primary and secondary windings of an ignition coil are wound around a core of wood.
- T F 8. Manufacturers often immerse ignition coil windings in oil to prevent them from rusting.
- T F 9. Condensers prevent distributor points from burning.
- T F 10. The condenser is connected directly across the distributor contact points.
- T F 11. The rapid collapse of the magnetic field, cutting the coil windings, induces the high voltage in the primary and secondary windings.
- T F 12. Condensers are made of alternate sheets of metal foil and insulating paper.
- T F 13. The condenser is left open at one end so it can be serviced easily.
- T F 14. It has been found that when a condenser is kept extremely dry, the life of the condenser is shortened appreciably.
- T F 15. The larger the foil and the thicker its dielectric, the greater the capacity of the condenser.
- T F 16. Condensers vary considerably in capacity, but most range from 1500 to 2500 microfarads.
- T F 17. Dirty terminals tend to decrease condenser efficiency.
- T F 18. The distributor is used to distribute electricity to such units as the horn, lights and radio.
- T F 19. The distributor shaft revolves at crankshaft speed on the two cycle engine.
- T F 20. Distributor shafts revolve at one-half crankshaft speed in four cycle engines.
- T F 21. The breaker points of a distributor are connected in series with the primary winding of the ignition coil.
- T F 22. Current passes through the breaker points only when they are opened by the breaker cam.

- T F 23. The breaker cam contains a lobe for each cylinder of the engine.
- T F 24. The high voltage charge from the coil passes down through the center terminal of the distributor cap.
- T F 25. Spark plugs get their high voltage charge from the outer cap electrode.
- T F 26. There is a rotor cap for each spark plug.
- T F 27. It is necessary to advance spark timing at high speeds and retard it at low speeds.
- T F 28. Retarded spark at high speeds is necessary to allow more time for the fuel to ignite and burn.
- T F 29. Vacuum advance produces the same results as centrifugal advance.
- T F 30. The vacuum advance operates from the high pressure developed in the exhaust system.
- T F 31. Since ignition coils have the ability to increase battery voltage, a low battery would not likely be a cause of poor ignition in starting.
- T F 32. The output of a given ignition coil is determined primarily by the length of time current flows in its secondary winding.
- T F 33. Cam angle determines the saturation of the primary winding of an ignition coil and the effective capacity of the condenser.
- T F 34. Cam angle or degree of dwell determines the length of time breaker points remain closed.
- T F 35. A condenser is used to lower voltage in the secondary winding of the coil.
- T F 36. If a condenser of incorrect capacity, either too large or too small, is used, it will cause the ignition points to burn.
- T F 37. One can tell by observing the condition of ignition points whether a condenser has excess or too little capacity.
- T F 38. Because of the expense involved, it is not common practice to replace the condenser each time points are replaced.
- T F 39. It is not necessary to follow manufacturers recommendation on setting ignition point clearance so long as the points open enough to break the circuit.

- T F 40. When newly mounted distributor points are found to be misaligned, they should be removed and another set of points installed.
- T F 41. Heat range of a spark plug is determined by its ability to transmit heat.
- T F 42. Hot range plugs are likely to last longer than cold range plugs if subjected to long, hard hours of continuous service.
- T F 43. Cold range plugs are less likely to cause preignition than hot range plugs.
- T F 44. Cold range plugs are less likely to foul out than hot range plugs.
- T F 45. One cannot generally determine the cause for spark plug fouling by a simple observation of plug points.
- T F 46. Spark plugs should always be drawn down extremely tight to prevent possible compression leaks.
- T F 47. Spark plug gap settings should be reset periodically because the gap tends to widen with use.
- T F 48. A spark plug's ability to utilize the total output of a coil may be decreased considerably if the plug is dirty or fouled.
- T F 49. The only positive way to check a coil or condenser is with ignition testing equipment.
- T F 50. The breaker point cam is caused to move due to the centrifugal force of the flyweight.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. The two types of ignition systems are the _____ system and the _____.
2. The ignition coil has a _____ winding and a _____ winding.
3. The insulating sheets of a condenser are called the _____.
4. The capacitance of a condenser is measured in _____.
5. Distributor points will arc and burn when poor condenser connections create more than _____ ohms of resistance.

6. Automatic spark controls are operated by _____ or by _____.
7. Automatic spark control is used to _____ and the timing of spark at high and low speeds.
8. The centrifugal spark advance controls spark timing by changing the position of the _____ or the _____.
9. The amount of centrifugal or vacuum spark advance necessary is determined experimentally with a _____ by the manufacturer and varies with each make and model of engine.
10. If the distributor shaft bushing is worn to such an extent that a measurement shows a clearance of _____ inch between the _____ and _____, bushing should be replaced before any attempt is made to adjust points.
11. Manufacturers specifications for spark plug gap setting generally range from _____ to _____ inches.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Components of the battery ignition system are:

- | | |
|-----------|-----------|
| (A) _____ | (E) _____ |
| (B) _____ | (F) _____ |
| (C) _____ | (G) _____ |
| (D) _____ | |

2. The types of shaft bearings that may be found in distributors:

- | | |
|-----------|-----------|
| (A) _____ | (C) _____ |
| (B) _____ | |

3. Five causes for reduced primary voltage are:

- | | |
|-----------|-----------|
| (A) _____ | (D) _____ |
| (B) _____ | (E) _____ |
| (C) _____ | |

4. Five conditions which might cause ignition points to burn are:

- (A) _____ (D) _____
(B) _____ (E) _____
(C) _____

PRINCIPLES AND FUNCTION OF THE MAGNETO

The magneto is a very unique and interesting mechanism. It contains its own condenser, points, coil and distributor system, and serves as a generator to produce its own power without the use of a battery. For these reasons it is almost exclusively used on lawn-mowers, outboard motors, and other similar gas engines.

A student who is preparing to repair small gas engines should acquire an understanding of magnetos, because he will certainly be required to repair and make adjustments on them.

In this assignment you will have the opportunity to learn of the different types of magnetos, the principles upon which they operate, and to compare their function to that of the battery distributor system.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- A. Purvis, All About Small Gas Engines, pp. 193-204, 239-243, 264-266.
- B. Lawn-Boy Service Manual, pp. 34, 26-31, 42, 84-89.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | | |
|---|---|----|--|
| T | F | 1. | A storage battery is not needed where the magneto is used. |
| T | F | 2. | The magneto generates voltage, steps up the voltage, and distributes it to the spark plug. |
| T | F | 3. | The low tension type magneto does not make use of an ignition coil. |
| T | F | 4. | The high tension magneto does not need an external coil to increase its voltage. |
| T | F | 5. | A magneto system is not generally used on small engines because of the inconvenience of having to carry a battery. |

- T F 6. The magneto is a very recent invention.
- T F 7. Magnetos do not require the use of permanent magnets.
- T F 8. A disadvantage of the magneto is that its voltage intensity does not drop at low speeds.
- T F 9. The revolving magnet magneto is also known as an induction magneto.
- T F 10. The oldest and most common type of magneto used on industrial engines is the low tension magneto.
- T F 11. The breaker points of a low tension magneto may be connected either in parallel or in series with the armature winding, but the parallel circuit will produce a higher voltage.
- T F 12. A high tension magneto steps up its voltage output by means of a primary and secondary armature winding similar to that of the ignition coil.
- T F 13. A safety gap is provided in high tension magnetos to prevent distributor points from burning when the condenser is bad.
- T F 14. An advantage of the magneto system over the battery system is that the need for points and condensers is eliminated.
- T F 15. A condenser is connected in series with the points to prevent arcing of the points.
- T F 16. The rotating magnet type magneto is made by only one company.
- T F 17. The magnet or magnets of a magneto are permanent magnets.
- T F 18. The flywheel magneto--a rotating magnet type--is used primarily on large engines which have flywheels.
- T F 19. In all induction magnetos, a cam opens the points at a time when the primary voltage is highest, which causes the magnetic field to collapse, inducing a high secondary (output) voltage.
- T F 20. Spark can be retarded or advanced either automatically or manually.
- T F 21. Spark can be advanced considerably by shifting the point at which the breaker points open.
- T F 22. The centrifugal spark advance is operated by two pawls which are mounted and held on the outward edge of the rotor by springs and are drawn inward, advancing the spark as the engine speed increases.

- T F 23. The degree of spark advance is controlled completely by the speed of the engine through the pawl stops and the springs holding the centrifugal weights.
- T F 24. The magneto produces a high voltage current.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. Magnetos are classified in three groups which are _____ magneto, _____ magneto, and _____ magneto.
2. The _____ on the magnet rotor circulates air to cool the magneto.
3. Current in the primary winding of a coil is produced in the secondary winding by _____.
4. In the rotating magnet design the magnet rotates and the _____, _____, and _____ remain stationary.
5. The interrupter is also known as the _____.
6. The rotating magnet magneto produces current as the rotation alternately cuts the _____ lines of force inducing _____ into the primary winding.
7. By means of _____, current is produced in the _____ winding when the primary current reaches a peak and the points open, causing the lines of force to _____.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. The manual spark advance is (A) commonly used; (B) seldom used; (C) used only on flywheel magnetos; (D) used only on low tension magnetos.
- _____ 2. The invention of the rotating magnet made the magneto (A) more complex; (B) harder to repair; (C) easier to repair; (D) larger and more sturdy.

Assignment
Sheet No. 10

Covering Units
124-128

PRINCIPLES OF MOWERS

American families are taking an increasingly greater amount of interest in their lawns. This has caused mower sales to multiply tremendously during the last ten years, and the repairman's work has increased accordingly.

The mower is not a complicated machine; however, there are a number of principles that one must understand in order to do acceptable servicing work.

In this assignment you will have an opportunity to study the principles of the mower and the terminology used in this phase of repair work.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- B. Lawn-Boy Service Manual, pp. 89, 90.
F. Fate-Root-Heat Company, Operating Instructions for the Model 900 Lawnmower Sharpener, pp. 5-7.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | | |
|---|---|----|--|
| T | F | 1. | A reel type mower cuts grass using the principle of a shear. |
| T | F | 2. | One purpose of the bed knife is to support the grass as the reel rotates and cuts it cleanly. |
| T | F | 3. | The work done by a bed knife is proportionately greater than any of the individual blades of the reel. |
| T | F | 4. | Because it is made of heavier and harder steel, the bed knife seldom needs sharpening. |
| T | F | 5. | The reel may be sharpened many times before the bed knife needs sharpening. |

- T F 6. Many times, mowers brought in for sharpening are only in need of adjustment of bed knife to reel.
- T F 7. The use of a fine sand compound is recommended when "lapping in" a mower reel.
- T F 8. Sharpening is 50% of the work when servicing a mower.
- T F 9. Resharpener a mower is actually a process of reshaping and matching of the reel blades to the bed knife.
- T F 10. Proper relief angles are necessary to insure that a mower will run easily and cut freely.
- T F 11. Because of production reasons most mower manufacturers "spin or cylinder" grind their reels.
- T F 12. In order to obtain desirable clearance, reel blades should be ground one at a time.
- T F 13. A power mower requires more clearance than does a hand mower.
- T F 14. It is a good idea to maintain a "condition check list" of all mowers brought to you for servicing.
- T F 15. The rollers should be checked for excessive wear when reconditioning a mower.
- T F 16. If a frame is twisted or "out of line," you should recommend that it be replaced.
- T F 17. A sprung reel blade may be forced back into place.
- T F 18. Few mower owners appreciate or are willing to pay for the cleaning and painting of their mower.
- T F 19. In most instances, it is unnecessary for you as a mower sharpener to check or replace crank case oil.
- T F 20. The handles of most mowers may be left in place during the sharpening operation.
- T F 21. Mowers that are hard to roll may be "cured" by lubricating the wheels.
- T F 22. As a safety precaution, all nuts, bolts and screws should be checked often for tightness.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. Wheel slippage may be caused by (A) use of a grease that is too heavy; (B) worn gears and pawls; (C) improper fit of tires; (D) accumulation of grass clippings in wheel housing.

- _____ 2. If a mower doesn't cut properly, or if grass is pulled out by its roots, one may assume that (A) the grass is too tough to cut; (B) mower needs oiling; (C) mower is adjusted to cut too low; (D) an improper relationship exists between the reel and bed knife.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. When a mower is brought in for servicing, the following checks should be made: (If possible check them in the presence of the customer.)

- | | |
|-----------|-----------|
| (A) _____ | (G) _____ |
| (B) _____ | (H) _____ |
| (C) _____ | (I) _____ |
| (D) _____ | (J) _____ |
| (E) _____ | (K) _____ |
| (F) _____ | (L) _____ |

SERVICING AND ADJUSTING THE LAWNMOWER

In the final analysis the performance of a mower is the basis upon which a customer judges a mechanic's work. With an understanding of mowers and their operation, you should be able to service and adjust them adequately with a minimum of experience.

In this assignment you will have an opportunity to learn the function of different parts of a mower, their relationships in the cutting process, and the common practices followed in sharpening and adjusting a mower.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- B. Lawn-Boy Service Manual, pp. 63-74, 83, 89-90.
- F. Fate-Roof-Heat Company, Operating Instructions for the Model 900 Lawnmower Sharpener, pp. 7-21.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | | |
|---|---|----|---|
| T | F | 1. | The first step in the sharpening procedure is to remove the bed knife. |
| T | F | 2. | A wire brush should not be used in the cleaning of dirt and grass from the bed knife. |
| T | F | 3. | A wavy appearance along the top face of the bed knife indicates excessive pressure between bed knife and reel. |
| T | F | 4. | A dull mower shows much "contacting" area over the entire thickness of the lip. |
| T | F | 5. | All bed knives have small holes drilled at their ends in order to accommodate mounting during the sharpening procedure. |
| T | F | 6. | When grinding gang mowers the bed knife attachment should be removed and adjusted to each individual bed knife. |

- T F 7. After the bed knife has been completely ground, a fine mill file or honing stone should be used to remove burns.
- T F 8. Bed knife end bolts must be securely tightened immediately after reinstalling the bed knife.
- T F 9. The split-bearing cone is used exclusively for reel bearings in today's mowers.
- T F 10. Hook grinding makes it possible to align the bed knife to the reel.
- T F 11. To align the bed knife in the grinder, you may use a small bubble level.
- T F 12. A five-bladed reel with a left-hand twist is considered the most common type of mower.
- T F 13. Grinding directions is determined by the twist or spiral of a reel.
- T F 14. The final adjustment of the bed knife must be made with varying pressure of the adjusting screws.
- T F 15. Inserting a slip of paper and rotating the reel backwards is a common method used in adjusting the reel and bed knife.
- T F 16. The paper test is the only way to get the blade ends adjusted perfectly.
- T F 17. Lapping is not a desirable method to use for sharpening a greens mower.
- T F 18. It is poor practice to attempt to seat the reel blades by pushing the mower across the floor.
- T F 19. Lapping compound may be removed simply by mowing grass for a few feet.
- T F 20. When lapping, both the reel and bed knife wear away at the same rate.
- T F 21. Bent aluminum housings may be straightened by pounding with a machinists hammer.
- T F 22. A rotary blade with insufficient "lift" will cause a mower to cut unevenly.
- T F 23. The rotary blade should be sharpened on both sides.
- T F 24. A file is suitable for use in the sharpening of rotary blades.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. An angle of _____ to _____ degrees is desired along the front edge of the bed knife.
2. Before starting to grind make sure your eyes are protected by _____ or a _____.
3. If mowers are not to be used immediately, _____ may be applied to ground surfaces to prevent rust.
4. Most power mowers today use tapered _____ bearings on the reel shafts.
5. If using the "hook principle" engage the hook about _____ inch from the front edge of the bed knife.
6. Any well _____ mower can be made into a silent mower.
7. A twisted rotary blade will produce a very _____ cut.
8. An improperly balanced blade is apt to cause _____ and loss of engine power.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. When grinding the front of the bed knife the wire edge (A) should be removed immediately; (B) will be removed when the top face is ground; (C) should be removed with a file after grinding; (D) should not be removed.
- _____ 2. "Clicking" at the end of reel blades may be prevented by (A) rounding the ends of the bed knife; (B) loosening the adjusting screw; (C) oiling the blades and bed knife; (D) tapering or rounding the ends of each reel blade.
- _____ 3. The reel of a power mower is driven by (A) the engine; (B) the wheels; (C) gears connected to the bed knife; (D) a rack and pinion gear system.
- _____ 4. The secret of a silent mower is lapping or adjustment to a clearance of (A) 1/100"; (B) 1/1000"; (C) 1/8"; (D) 1/4".

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Three other names by which the bed knife is sometimes identified are:
(A) _____ (C) _____
(B) _____
2. Two ways by which bed knives are held in the mower are:
(A) _____ (B) _____
3. The following steps should be taken prior to reel grinding on power mowers:
(A) _____
(B) _____
(C) _____
(D) _____
4. The causes of "wavy wipe" of reel blades on the bed knife are:
(A) _____
(B) _____
(C) _____
5. To remedy "wavy wipe" one should:
(A) _____
(B) _____
(C) _____
6. Exhaust port examination will reveal:
(A) _____ (B) _____

CHAIN SAW SHARPENING

Seldom today can you drive through a wooded area without hearing the "whine" of a chain saw in use. During recent years the use of chain saws has become increasingly popular due largely to the speed and ease they contribute to the woodman's work.

The performance and life of any chain depends upon how well it is maintained. If the filing or grinding is 50% below standard, the performance of the chain will also be 50% below standard; therefore, the necessity of your doing a "good job" of sharpening is extremely important.

In this assignment you will be expected to learn some of the basic information regarding the sharpening and maintenance of chain saw chains.

Assignment:

1. Read the references listed below.
2. Talk with local chain saw dealers and if available obtain the operating and instruction manuals for their make of saw.

References:

- G. Fate-Root-Heat Company, Operating Instructions for the Peerless Saw Chain Grinder, pp. 4-16.
- K. Long, Small Engines Service Manual, pp. 32-38.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | |
|---|---|---|
| T | F | 1. Maintenance procedures may often be blamed for poor chain performance. |
| T | F | 2. When inspecting a chain, take notice that all parts are of the correct size and are not installed backwards. |
| T | F | 3. A chain that is cutting properly will stay sharp longer. |
| T | F | 4. Chain "stretch" is caused by the gradual wearing down of the bar rails due to continued use. |
| T | F | 5. Due to the high speed of the chain, adequate lubrication of the chain is seldom achieved while it is in service. |

- T F 6. If the chain becomes loose during operation, the tension should be readjusted while the chain is still warm.
- T F 7. A chain that is loose has a tendency to chatter and bounce in the cut.
- T F 8. Proper "break in" procedure requires that all excess oil be wiped off the chain.
- T F 9. During chain "break in" the saw should not be run in excess of $3/4$ throttle.
- T F 10. A chain pitch of $5/8$ " will require use of a round file size of $3/16$ ".
- T F 11. Costly chain breakage may be caused by nicking drive links and tie straps when grinding or filing.
- T F 12. Because of the difficulty in maintaining proper angle by hand filing, the chain should be re-machined on a grinder.
- T F 13. The top plate cutting angle cannot be changed without affecting the side plate angle.
- T F 14. The depth gauge is often referred to as having the same action as a pocket knife.
- T F 15. Long chain life is dependant upon the depth gauge setting.
- T F 16. Hard or frozen wood requires a lower depth gauge setting than does softer wood.
- T F 17. The top surface of the depth gauge should have a flat length of at least two times its width.
- T F 18. A 12C Oregon chain with a $3/8$ " pitch should have a factory set clearance of .030 inches.
- T F 19. The saw bar acts as a guide and a support for the chain and it holds it in position to perform its job.
- T F 20. Because of the inaccuracy of hand filing, the height of the chain saw teeth should be measured and the side with the shortest teeth ground first.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. A properly maintained chain is very strong, with even the smallest being capable of lifting _____ pounds; however, poor maintenance can reduce the strength to less than _____ pounds.

2. The angle to be maintained on the side plate is exactly _____.
3. Weakening of drive links are easy to recognize because of the _____ and _____ in the saw, bar, sprocket, and chain.
4. Chains that run too loose will _____ at all times while cutting.
5. When "shock loads" result, the _____ cannot drive the chain smoothly.
6. Determination of proper depth gauge setting is regulated by _____, speed of chain travel, and _____.
7. Spread rails, unsquare rails, and shallow grooves cause the chain to _____ from the cut, thus giving a kerf that is _____ than the bar.
8. A chain joint that is too _____ will cause chain damage.
9. When making guide bar repairs, if the rails are spread, they may be closed by inserting a shim _____ inches thicker than the chain drive tangs and closing the rails upon the shim.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. Factors which shorten chain life are (A) bar and sprocket maintenance; (B) frequency of sharpening; (C) dirt; (D) all of these.
- _____ 2. The correct top plate angle is (A) 20°; (B) 25°; (C) 30°; (D) 35°.
- _____ 3. The top plate cutting angle should be (A) 50°; (B) 60°; (C) 75°; (D) 90°.
- _____ 4. When the bar groove opens up too wide the cause is probably (A) uneven filing or dull cutters; (B) chain "pulling" to one side; (C) rounded edge on bar rails; (D) defect in the metal bar.
- _____ 5. When hand filing a chain, a right handed person has a tendency to file the left hand cutters (A) wider than the right hand cutter; (B) narrower than the right hand cutter; (C) shorter than the right hand cutter; (D) higher than the right hand cutter.

- _____ 6. To clean a chain after daily use, it is best to use
(A) wire brush; (B) stiff bristle brush; (C) soft
bristle brush; (D) cloth.
- _____ 7. The average depth gauge setting for a chipper chain with
a 3/8" chain pitch is (A) .50"; (B) .20"; (C) .050";
(D) .020".

Listing

Directions: List the items called for in each of the following.
Select your answers carefully.

1. Five reasons a chain may not hold an edge are:

- (A) _____
- (B) _____
- (C) _____
- (D) _____
- (E) _____

2. Correct chain tension is important because:

- (A) _____
- (B) _____
- (C) _____

3. When the depth gauge setting is incorrect, it may cause:

- (A) _____ (D) _____
- (B) _____ (E) _____
- (C) _____ (F) _____

4. Three saw chain types in popular use are:

- (A) _____ (C) _____
- (B) _____

OUTBOARD MOTOR LOWER UNITS AND PROPELLERS

Within the past several years there has been a tremendous growth in the small boating industry. Fishing, water skiing, and pleasure riding have become increasingly popular family past-times.

Due to the increased use of outboard motors, it is important for the general mechanic to know how to service them.

Small gas engine principles, repair and maintenance have been covered in previous units so it will be necessary for you to apply these principles to the powerhead of the outboard motor.

In this unit you will be expected to learn about the "lower unit" and the propeller of an outboard motor.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- L. Evinrude Motors, Service Manual, Fifth Edition, Section V, pp. 1-12.
- M. Johnson Motors, Propellers, RPM, and Performance, pp. 1-8.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | |
|---|---|---|
| T | F | 1. As horsepower increased and the scope of outboard use broadened, it became necessary to consider the proper selection of propellers. |
| T | F | 2. Peak horsepower range is the point at which the maximum r.p.m. is attained. |
| T | F | 3. An engine's power output is directly proportioned to r.p.m. |
| T | F | 4. Many factors must be considered to insure the correct selection of propellers. |
| T | F | 5. The pitch and diameter of a propeller determine the rate of motor r.p.m. |

- T F 6. Theoretically and figuratively speaking, a 6" pitch propeller will advance 6" in one full revolution of the propeller.
- T F 7. A standard propeller will usually not prove adequate to pull a water skier who is of light to medium weight.
- T F 8. Pitch is defined as the "twist" or angle of the propeller blade in relation to direction of boat travel.
- T F 9. Leaking water tubes or connections in the driveshaft casing can be the cause of water entering the motor crank-case or the gear case.
- T F 10. Excessive loss of oil or grease in the gear case may be caused by water leaks.
- T F 11. Chemical treatments of gear case castings have proven to be of little value in retarding salt water deterioration.
- T F 12. Water pumps, water scoops, and water outlets are usually a separate part of the lower unit.
- T F 13. The two-stage centrifugal pump is used primarily on the smaller outboard motors.
- T F 14. Ports for water discharge on the impeller type pump are a separate part of the aluminum housing.
- T F 15. Flexing of the impeller blades make the "centri-matic" type pump a displacement pump at low speeds.
- T F 16. The pumping action of the impeller blades is obtained when the volume of space created is at its lowest.
- T F 17. While in "reverse", excessive back pressure is created when the water flows out the normal exhaust outlet.
- T F 18. If no data bulletins or exploded drawings are available, the lower unit should be disassembled in logical sequence.
- T F 19. When disassembling the lower unit, all oil or grease should be removed from the gear housing.
- T F 20. Prior to installation, oil or grease seals should be well lubricated to permit placement without rolling or tearing.
- T F 21. Shafts should be free from excessive binding before installing the gear housing on the motor.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. Load applied to a motor is largely governed by the _____ and _____ of the propeller.
2. As the revolving propeller draws water from the front and discharges it to the rear, it creates what is known as a _____.
3. Driveshaft casings are usually of _____ construction or of _____, provided with flanges for mounting.
4. Loose water tubes contribute greatly to faulty cooling systems, therefore, it is necessary that all _____ be water tight.
5. Driveshaft casings must be _____ and _____.
6. In the past, _____ was generally used to help combat the ravages of salt water.
7. The impeller blades flex or bend as they _____ in the housing.
8. After the gear case has been disassembled, all parts should be cleaned by washing in a _____ and drying with _____.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Although many factors affect propeller selection, eight common details to be considered are:

- (A) _____
- (B) _____
- (C) _____
- (D) _____
- (E) _____
- (F) _____
- (G) _____
- (H) _____

2. The lower unit is defined as that part of the outboard motor assembly which is comprised of:
- (A) _____ (D) _____
- (B) _____ (E) _____
- (C) _____
3. To accomplish "foreward," "neutral," and "reverse," three different members are needed:
- (A) _____ (C) _____
- (B) _____
4. Noise and vibration in the lower unit is likely to be caused by:
- (A) _____
- (B) _____
- (C) _____
- (D) _____
5. The life of the lower unit components is directly dependant upon the circulation of the proper type of clean lubricant, proper amount of lubricant and the following factors:
- (A) _____
- (B) _____
- (C) _____
- (D) _____
- (E) _____

SADDLE AND STEERING ASSEMBLIES

Bicycles are used in some respects like automobiles in that they are used for both business and pleasure. The comfort of the rider is very important, and is dependent largely upon the mechanical condition of the saddle. Steering is, of course, extremely important and must always be in proper adjustment to promote safety and ease of handling.

Although this phase of the bicycle will not require a great deal of repair, it is nevertheless important that you understand it in gaining a knowledge of the whole bicycle.

In this assignment you will have the opportunity to become acquainted with the parts of the saddle and steering assemblies and to study their relationships to each other.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- C. Temple Press Limited, Cycling Book of Maintenance, pp. 1-8, 117-119.
- D. McFarlane, It's Easy to Fix Your Bike, pp. 4-5, 12.
- E. Kraynick, Bicycle Owner's Handbook, pp. 23-39.

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | | |
|---|---|----|---|
| T | F | 1. | The two alternative methods used for connecting the handlebar and fork are the cone expander type and the clip (clamp) steering head. |
| T | F | 2. | The split in the lower end of the handlebar stem is to provide for expansion as the cone is drawn into the stem. |
| T | F | 3. | When disassembling the steering mechanism, the head tube is removed from the frame. |
| T | F | 4. | When removing the fork assembly, the ballbearings (from the races) may be removed for inspection and cleaning. |

- T F 5. When retightening the expander bolt steering, it is important that the expander bolt be as tight as possible.
- T F 6. The handlebar stem may be removed by extracting the expander bolt.
- T F 7. More range of saddle adjustment is allowed in the pin type saddle pillar than in the angle or L type pillar.
- T F 8. In the clip type of fixing, the clip takes the place of the adjustable race.
- T F 9. In order for one to obtain greatest efficiency in pedaling, the seat should be adjusted so the heel just touches the pedal when the leg is held straight.
- T F 10. The clip type assembly utilizes a clip (clamp) bolt to tighten the handlebar stem in the fork stem.
- T F 11. Adjusting handlebar height can be accomplished on most all types of bicycles after either loosening the expander bolt or clip (clamp) bolt.
- T F 12. If when riding seated, there is a tendency to place excessive "pull" on the handlebars, this condition can be corrected by lowering the front of the saddle.
- T F 13. The bicycle industry has standardized fork stem diameters so that they are interchangeable from one make bicycle to another.
- T F 14. Each new fork stem has to be cut to the length required by the specific bicycle on which it is to be used.
- T F 15. To replace the old type handlebar grip with the new type longer one, one must also replace the old handlebars with the new, longer ones.
- T F 16. No satisfactory method has been developed to secure handle-grips to handlebars.
- T F 17. When adjusting the head race, the most important thing to consider is that the wheel turns freely and easily.
- T F 18. Because the fork is a part of the steering mechanism, one should not attempt to straighten it but should remove and replace it with another.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. Two methods of fastening handlebars to forks are _____ and _____.

2. The front forks consist of a fork crown into which are brazed or welded two fork blades and a fork _____.
3. The most common diameter of the ball bearings in the steering assembly is _____ inch.
4. The handlebar stem should always be inserted into the fork stem a minimum of _____ inches.
5. Before the final tightening of the clip (clamp) bolt, the handlebar should be aligned with the _____.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. If a handlebar stem is difficult to remove, the probable cause is (A) wrong cone in use; (B) expander bolt has been tightened too tight; (C) wrong expander bolt in use; (D) cone has expanded from temperature.
- _____ 2. The lamp bracket is held in position by (A) handlebar; (B) expander bolt; (C) adjustable-race; (D) locking ring.
- _____ 3. When storing a bicycle, a good method is to (A) stand upright and cover with cloth; (B) lay flat on floor; (C) hang from ceiling; (D) none of these.
- _____ 4. If a customer's bicycle seat promotes discomfort the best course of action is (A) replace pillar; (B) reupholster seat with softer material; (C) readjust seat position; (D) nothing can be done.
- _____ 5. The adhesive used to attach grips to handlebars is (A) rim cement; (B) animal glue; (C) shellac; (D) none is used.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. The three parts of a handlebar assembly are:

(A) _____ (C) _____
 (B) _____

2. Three common types of seat posts are:

(A) _____ (C) _____
 (B) _____

Assignment
Sheet No. 15

Covering Units
173, 174, 180-187
189-193, 195-200, 205

WHEELS, HUBS AND DRIVE MECHANISMS

The hub, wheel, chain, and pedal assembly are the means by which a bicycle rider propels himself. The relative ease or difficulty with which this can be accomplished depends upon a number of things, many of which you, as a mechanic, can control. "Ease of operation" is the factor that determines whether riding is to be a pleasure or is to be classified as work.

It will be your responsibility to see that any bicycle you repair performs at its best. Whether a bicycle is ridden for business or for pleasure, the rider will be interested in having it operate smoothly, requiring as little of his energy and effort as is possible.

In this assignment you will have the opportunity to study the hub, wheel, and drive mechanisms and to become familiar with the principles upon which they operate.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- C. Temple Press Limited, Cycling Book of Maintenance, pp. 9-50, 126-130.
- D. McFarlane, It's Easy to Fix Your Bike, pp. 6-11, 13-16, 27-29.
- E. Kraynick, Bicycle Owner's Handbook, pp. 40-56, 65-77.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | |
|-------|---|
| T F | 1. Rear hubs are of a single standard design in most all makes of bicycles. |
| T F | 2. Wheel cones are used for the purpose of holding and adjusting wheel bearings in the hubs. |
| T F | 3. If two sprockets, each with different gear teeth, are on the hub, the wheel may be turned around to obtain a different gear ratio. |

- T F 4. The rear hub spindle is attached to the frame by means of two forks into which the spindle fits.
- T F 5. Most hubs are built so that when tracks and races become worn they can be replaced without replacing the hubs.
- T F 6. If one ball of a set is damaged, the whole set must be replaced.
- T F 7. When adjusting bearings, all end and side play should be removed.
- T F 8. The hub should be filled with oil until it is visible at the end of the shaft.
- T F 9. A sprocket can best be removed by tapping it loose with a hammer.
- T F 10. Sprockets must be turned to the left for removal.
- T F 11. Although most free-wheel hub gears contain two pawls, only one pawl is in use at any given time.
- T F 12. The free-wheel hub also contains a built-in brake.
- T F 13. The bottom bracket is the most highly stressed unit on a bicycle because it supports the entire weight of the rider.
- T F 14. The bottom bracket consists of a tube into which the crank assembly is fitted.
- T F 15. The bottom bracket axle is held in place within the shell by two sets of ball bearings.
- T F 16. The fixed or stationary ball cup is fastened in place by a press fitting into the bracket liners.
- T F 17. When replacing balls, insert as many as will fit into the race in order to rub off "corners."
- T F 18. When installing new crank cotters, it may be necessary to file the corners of the keyways to permit the installation of the cotters.
- T F 19. If any of the balls of the bearings are corroded or pitted, they should all be replaced.
- T F 20. Ball bearings and track sizes are standardized by manufacturers permitting universal interchangeability of parts.
- T F 21. Light grease rather than oil is preferred for lubricating bottom bracket bearings.

- T F 22. Right pedals have right-hand threads and left pedals have left-hand threads.
- T F 23. When the chain wheel shows wear and a replacement is not available, it is best to refit the old chain.
- T F 24. Bicycle chains tend to stretch, rather than wear, under heavy and continued use.
- T F 25. As a chain wears, it operates progressively farther out toward the end of the chain wheel tooth.
- T F 26. The best position in which to straighten a crank is with it assembled in the bracket so that its correct position can be easily determined.
- T F 27. Bracket bearings should be tightened until they bind so they will operate freely when "broken in."
- T F 28. A cut or machined chain wheel is considered slightly better than a pressed or die-cut wheel.
- T F 29. Chain wheels are attached to cranks with threads for easy removal.
- T F 30. Pedals screw into crank arms with left-hand threads on left pedal and right-hand threads on right pedal to prevent their becoming loose while in motion.
- T F 31. Pedals turn on ball bearings that are adjusted by means of a cone.
- T F 32. The pedal spindle has the same diameter at both ends, giving it added strength.
- T F 33. A "rat-trap" pedal is one which can be completely disassembled.
- T F 34. Very accurate adjustments are required for pedal bearings.
- T F 35. A fourteen-gauge spoke is of larger diameter than a sixteen-gauge spoke.
- T F 36. Overloading of wheels can be caused by too light spokes, as well as by overloading by the weight of the rider.
- T F 37. The most common type of spoking used today is the "tangent arrangement."
- T F 38. A common difficulty encountered in wheel maintenance is the frequent breakage of spoke nipples.
- T F 39. On bicycles not used for racing the rims are of a design that accommodates either stirrup or caliper brakes.

- T F 40. A thin coat of oil over the tire walls will help to preserve and protect the rubber.
- T F 41. A one-half inch pitch chain is designed so that each space in the chain engages a sprocket tooth.
- T F 42. The one inch and the one-half inch pitch chains are interchangeable.
- T F 43. When adjusting chain tension, at its tightest, the chain must have $\frac{1}{4}$ inch of slack.
- T F 44. When the crank eye thread has been stripped, the crank must be removed and replaced.
- T F 45. Crank widths and threads differ with makes of bicycles and are therefore not always interchangeable.
- T F 46. A chain adjuster is standard equipment on all makes and models of bicycles.
- T F 47. American bicycle wheels have 36 spokes in each wheel, while an English or continental model usually carries more spokes in the rear wheel than in the front wheel.
- T F 48. If a wheel is out of line, it can best be straightened by laying it on a block and applying pressure with the foot.
- T F 49. If a wheel hub has been ruined, it should be replaced without loosening the spokes or otherwise getting the spoke tension out of adjustment.
- T F 50. Each thirty-six spoke hub has two flanges, each having thirty-six spoke holes.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. For tightening or loosening a sprocket, one should use a _____ wrench.
2. The two points of greatest wear in a free-wheel hub are the _____, and _____.
3. The projections found on the cones of the front hub are called _____, and their function is to _____ the wheel in the fork.
4. In checking chain wear, the normal maximum allowable difference in the contracted and extended lengths is _____ inch, or if the wheel is in good condition and worn evenly, a difference of _____ inch may be tolerated.

5. A chain wheel that is slightly thicker on the outer edge next to the teeth is called a _____ wheel.
6. Different types of bicycle wheels may generally be found to contain different numbers of spokes, but the most common wheels contain either _____, _____, or _____ spokes.
7. The size or diameter of wheel spokes is referred to as spoke _____.
8. In adjusting chain tension, one should be sure to keep the slack limited to a minimum movement of _____ inch and a maximum movement of _____ inch.
9. When a rear sprocket is replaced with a larger one, one or more _____ must be added to the chain.
10. A boy's bicycle usually has a _____ tooth front (chain) sprocket, while a girl's bicycle usually has _____ teeth in the front sprocket.
11. A boy's bicycle having a 24-inch tire, 26-tooth front (chain) sprocket, and a 10-tooth rear sprocket will travel _____ inches in one turn of the crank.
12. A bicycle having a 26-inch tire, a 26-tooth front (chain) sprocket, and a 10-tooth rear sprocket will have a gear of _____.
13. A bicycle having a 26-inch tire and a 26-tooth front (chain) sprocket would need a _____ tooth rear sprocket to produce a 72-gear bicycle.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. A sprocket is (A) used to hold bearings in hubs; (B) used to attach hubs to frame; (C) a gear by which the chain pulls the bicycle; (D) part of a bicycle chain.
- _____ 2. By attaching a sprocket to each end of a hub, (A) gear ratio can be changed by reversing wheel; (B) bearings can be more accurately adjusted; (C) chain life will be extended; (D) wheel can be attached more securely to frame.
- _____ 3. Sprockets of sports bicycles are usually (A) made as a part of the hub; (B) screwed onto the hub; (C) riveted to the hub; (D) welded to the hub.

- _____ 4. The purpose of the bottom bracket is to (A) hold frame together; (B) hold the seat in place; (C) attach pedal to crank; (D) mount pedal crank.
- _____ 5. If small pits are visible as a result of corrosion, the ball cup should be (A) cleaned with fine emery cloth; (B) removed and replaced; (C) oiled to prevent further corrosion; (D) washed thoroughly with paraffin.
- _____ 6. A badly worn chain wheel can be detected by (A) measuring diameter of the wheel; (B) observing amount of slack in the chain; (C) observing hooked shape of its teeth; (D) length of time it has been in service.
- _____ 7. When tracking properly, a chain should (A) appear to cling to the wheel as it becomes disengaged; (B) flow smoothly over the wheel; (C) attempt to ride high on the end of the tooth as the chain engages the wheel; (D) have slack on top side of the cycle of chain.
- _____ 8. When crank cotters fail to fit properly, a satisfactory solution is to (A) file larger slot in crank; (B) insert the cotter by force; (C) replace crank assembly; (D) file cotter.
- _____ 9. A wavy or otherwise untrue chain wheel should be (A) replaced with a new wheel; (B) straightened; (C) left to run, as it can do no harm; (D) turned around on crank so as to change its direction of rotation.
- _____ 10. The purpose of applying French chalk when repairing a tube is to (A) aid in location of puncture; (B) reduce stickiness of exposed cement; (C) aid in reduction of tube "pinch"; (D) help reduce "high spots" on inside of tire casing.
- _____ 11. A double-buttet spoke is (A) larger at both ends than at the center; (B) larger at center than at ends; (C) larger than a single-buttet spoke; (D) smaller than a plain spoke.
- _____ 12. To compare the tension on wheel spokes one may (A) pluck spokes with fingers and compare their sounds; (B) apply pressure on spoke to estimate tightness; (C) check to see if straight; (D) run nipples on all spokes up the same number of turns.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Three causes of a spoke breakage at the neck are:

- (A) _____
- (B) _____
- (C) _____

2. Two kinds of chain links are:

(A) _____ (B) _____

3. The three common patterns of wheel rims are:

(A) _____ (C) _____

(B) _____

HAND AND HUB BRAKES

Hand-operated brakes were once considered luxuries found only on English lightweight bicycles, but they are rapidly becoming more common on American makes, especially the lightweight and sports models. It is also true that a large per cent of the lightweight bicycles sold in the United States are of English manufacture and come equipped with hand brakes.

For the above reasons, and as a matter of safety it is extremely important that you know the different types of brakes available and the principles upon which they operate.

In this assignment you will have the opportunity to study the principles of hand brakes and to become familiar with the common terms employed in brake mechanics.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- C. Temple Press Limited, Cycling Book of Maintenance, pp. 51-70.
- D. McFarlane, It's Easy to Fix Your Bike, p. 17,

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | | |
|---|---|----|---|
| T | F | 1. | The caliper brake is the most commonly used brake on English type sports bicycles. |
| T | F | 2. | The caliper brake is so called because it resembles an engineer's caliper. |
| T | F | 3. | A disadvantage of the caliper brake is that the brake must be disturbed when the wheel is removed. |
| T | F | 4. | The caliper brake shoe stops the bicycle by friction created as the shoe is pressed against the side of the tire. |

- T F 5. To brake evenly, both brake shoes of a caliper brake must be adjusted to lie equidistant from the rim.
- T F 6. There is greater strain on the pivot bolt on rear brakes than on front brakes.
- T F 7. Brake blocks should be adjusted as close to the rim as possible without touching the rim.
- T F 8. Brake blocks should be oiled at frequent intervals.
- T F 9. The hand-brake cable does not require oiling.
- T F 10. Hand-brake cable nipples, when soldered properly, should be stronger than the cable itself.
- T F 11. The stirrup is so called because it is made in the shape of a saddle stirrup.
- T F 12. Stirrup brakes are used only on rear wheels.
- T F 13. Brake adjustments should be made at the handlebar rather than at the stirrup.
- T F 14. A disadvantage of the hub brake is that should the drum hole become clogged, oil tends to run down onto the brake linings.
- T F 15. Hub brake shoes are made of metal.
- T F 16. Aluminum brake shoes should not be washed with sodium carbonate (washing soda) because of its corroding effects.
- T F 17. Oil on brake linings may be removed satisfactorily by using lighter fluid or a clothes cleaning compound.
- T F 18. Dirt or glaze may be removed from brake linings satisfactorily with sandpaper.
- T F 19. A hammer may be used to remove brake blocks.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. The stirrup brake is also known as a _____ brake.
2. Caliper brake shoes are held away from the rim by a _____.
3. Action of the brake hand lever is transferred to the brake shoe by a _____ connecting the two.
4. A _____ is used to house the cable.

5. Brake cables may be kept working freely by periodically injecting _____ into the casing.
6. The stirrup brake lever is held in the "off" position by a _____.
7. The condition of the rim and the weather have less effect on _____ brakes than they do on either the stirrup or caliper type brake.
8. The brake drum is protected from mud and other external matter by a _____ located at the bottom of the cover plate.
9. The main reason for dismantling the brake drum is to reline the shoes if the linings have become covered with _____ or have worn out.
10. Brake shoes are forced against the hub by a _____ and are returned to their original "off" position by a return _____.
11. Brake shoes are made of _____ and _____.
12. Squealing and shuddering can be prevented by _____ the ends of the linings after their installation.
13. Before rim brakes can be adjusted, the wheel must run free from _____ and be _____ in the fork.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. A badly dented rim will most likely cause a caliper brake to (A) not work at all; (B) work perfectly normal; (C) grab and skid; (D) ruin wheel.
- _____ 2. The brake cable is made of (A) solid steel; (B) stranded steel; (C) stranded aluminum; (D) solid brass.
- _____ 3. The shoe of a stirrup brake works against the (A) inner edge of the rim; (B) outer edge of the rim; (C) edge of the tire; (D) tread of the tire.
- _____ 4. Brake shoe lining rivets are countersunk (A) the thickness of the rivet head; (B) as deeply as possible; (C) one-half the lining thickness; (D) only when factory made parts are available.

- 5. Rotating the cam when the assembly is removed from the drum is likely to (A) cause no harm; (B) damage the cam; (C) weaken the return spring; (D) damage the shoe.
- 6. Oily brake linings should be (A) removed and replaced; (E) washed with a stiff brush and gasoline; (C) wiped with clean cloth; (D) left as they are.

Assignment
Sheet No. 17

Covering Units
216-217, 222-223,
225, 227, 229-233

HUB GEARS AND COASTER BRAKES

Many of the criticisms of bicycles stem from the performance of the rear hub. It is no doubt one of the most important parts of a bicycle and can be expected to require as much or more maintenance and repair than any other part of the bicycle. There are several kinds of hubs, all of which will give very satisfactory service when correctly assembled, adjusted, and lubricated.

In this assignment you will have the opportunity to study the working principles and parts of hub gears and coaster brakes.

Assignment:

1. Read the references listed below.
2. Answer the questions below and turn in this assignment by _____.

References:

- C. Temple Press Limited, Cycling Book of Maintenance, pp. 71-104.
- D. McFarlane, It's Easy to Fix Your Bike, pp. 18-26, 30-36.
- E. Kraynick, Bicycle Owner's Handbook, pp. 78-114.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | |
|---|---|---|
| T | F | 1. Hub-gear wheel bearing adjustments are made by adjusting the position of the left-hand wheel cone. |
| T | F | 2. The right-hand cone is used only for the purpose of adjusting the position of the gears. |
| T | F | 3. The right-hand cone adjustment is made by the rider as he sees the need for it. |
| T | F | 4. It is not good practice to remove all of the play from wheel bearings because they tend to become defective if too tightly adjusted. |
| T | F | 5. Wheel cones may need to be replaced if oil is found to be seeping to the outside. |

- T F 6. Any good grade lubricant is sufficient for oiling hub gears.
- T F 7. Very heavy oil should be used to lubricate hub gears to prevent its running out past the cones.
- T F 8. Hub gears are of recent development, having been in use only five or ten years.
- T F 9. There is only one manufacturer of variable speed hub gears.
- T F 10. Care must be taken to prevent the indicator from becoming unscrewed inside the hub.
- T F 11. Chain-stay ends must be parallel before attempting to fit a variable gear hub to a bicycle.
- T F 12. When adjusting the indicator rod, be sure the control lever is in the No. 1 position.
- T F 13. Regardless of the many hub types, the indicator rod is adjusted to the same general position.
- T F 14. It is necessary to use separate gear control triggers for three and four speed machines built within the last ten years.
- T F 15. The trigger control must be removed from the handlebar when installing a new wire.
- T F 16. A 54½-inch inner wire cable is the most commonly used control wire and will fit most frame sizes.
- T F 17. On certain type hubs, care must be used when fastening the control wire to the indicator chain in order that the two "line up."
- T F 18. Whenever a hub is dismantled, its component parts should be thoroughly inspected.
- T F 19. When reassembling Sturmey-Archer hubs, it is usually most convenient to reconstruct certain minor assemblies first.
- T F 20. The derailleur gear has most of its working parts protected from the weather.
- T F 21. With derailleur gears, the chain is shifted to different size sprockets to obtain speed changes.
- T F 22. A rider must never "back-pedal" while changing gears with a derailleur system or he will upset the "tensioning."

- T F 23. "Dishing" is a process of flattening the rim along one side in order to bring it into a new central position.
- T F 24. When fitting the chain to a derailleur gear, position the gear lever to the No. 2 position.
- T F 25. Efficient operation of a derailleur gearing system is dependent upon initial fitting, adjustment and proper lubrication.
- T F 26. When changing gears, the rider should gently ease the pressure on the pedals and change the gear as rapidly as possible.
- T F 27. The coaster brake is not generally used on English or continental bicycles.
- T F 28. The brake action of the New Departure brake is developed by friction as the discs are forced together.
- T F 29. Brake action in the Bendix and Higgins brakes is developed by the friction of expanding stationary brake shoes on the inside of the hub.
- T F 30. Each of the discs of a New Departure brake is different.
- T F 31. Each of the different coaster brakes employs a different type of driving mechanism.
- T F 32. The primary difference between various makes of coaster hubs lies in the different mechanisms employed to secure braking action.
- T F 33. One of the primary criticisms of the coaster brake hub is that forward action is usually delayed by a slow or slipping action when one starts to turn the crank pedal.
- T F 34. If some of the discs of a New Departure brake are scored, it is advisable to remove all the discs and replace with a new set.
- T F 35. All New Departure brake disc sets are interchangeable.
- T F 36. The wheel sprocket nut has a left-hand thread.
- T F 37. If, after the proper initial adjustment of the cone, the shaft clicks when pushed endwise, the cone should be tightened one-sixteenth turn at a time until satisfactory adjustment is obtained.
- T F 38. The repairman who finds a damaged sprocket on a Bendix hub may substitute a Morrow sprocket quite satisfactorily.

- T F 39. The Bendix brake uses two cones, both of which are movable, to expand the brake shoes.
- T F 40. If parallel grooves are visible in Bendix brake shoes, they should be removed and replaced.
- T F 41. It has been found through experiments over a period of years that sudden starts and stops do not affect the life of a coaster brake.
- T F 42. High-temperature sludge is a condition wherein heat from friction has burned all of the grease in a hub, reducing it to gritty, sandy particles.
- T F 43. In most cases poor brakes can be corrected by tightening and adjusting the brake shoes.
- T F 44. If regular ball bearing grease is not available, vaseline may be used as a temporary substitute to lubricate rear hubs.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. If play develops in the wheel bearing of a Sturmey-Archer hub, it should be removed by adjusting the _____ cone.
2. The Sturmey-Archer hub-gear indicator rod is adjusted while in _____ position.
3. Adjustment of the type F Sturmey-Archer gear is accomplished by changing the _____ of the control cable.
4. Sturmey-Archer and other varieties of _____ are produced in various speed ranges.
5. Whenever you dismantle any hub, the order and number of _____ must be noted so that they may be put back correctly when reassembling.
6. Ball races must be examined for _____ or other signs of wear during dismantling and inspection process.
7. In general, the Sturmey-Archer hub may be reassembled by _____ the disassembly process.
8. With the FW hub, install a new _____ if new balls and a new retainer have been fitted.
9. When the indicator chain is moved up and down, the sliding _____ must be free to move along the axle.

10. If you break the gearshift cable of a Higgins or Sturmey-Archer assembly, the hub will go into _____ gear.
11. Never use _____ when lubricating the Higgins or Sturmey-Archer hub.
12. One method of checking gearshifts is to shift from _____ to normal and notice if the pedal "lets go" about halfway between lever positions.
13. The first step when replacing gearshift cables is to disconnect the cable from the _____.
14. With a Bendix Multispeed gear, the bicycle is in _____ gear when the sun gear is pulled into the stationary gear teeth.
15. When a Higgins or Sturmey-Archer hub is in low gear, the _____ pin will be extended out from the indicator rod.
16. Smooth brake shoes or grease on a braking surface will probably cause slow _____ action.
17. When oiling coaster brakes it is best to use SAE _____ or _____ grade motor oil.
18. To lubricate the hub, a good grade of thin, non-gumming _____ should be used.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. The internal gear position of a three-speed Sturmey-Archer hub is (A) adjusted by the right-hand cone; (B) not adjustable; (C) adjusted by setting position of indicator rod relative to end of axle; (D) adjusted by changing to a different size sprocket.
- _____ 2. Sturmey-Archer gears may be adjusted into correct operating position by observing (A) position of indicator projecting from left end of hub; (B) position of shoulder on indicator at right-hand end of hub; (C) either A or B, depending on model of hub; (D) neither A nor B.
- _____ 3. When inspecting any Sturmey-Archer hub, check to ascertain that the right-hand ball ring contains exactly (A) 18 balls; (B) 24 balls; (C) 30 balls; (D) 36 balls.
- _____ 4. The marked teeth of a FW wide range four-speed hub should be placed so that they (A) point inward; (B) match marks on the small pinion; (C) are placed alternately inward and outward; (D) point radially outward.

- _____ 5. When reassembling the FW hub, the amount of oil needed before inserting the assembly into the hub shell is (A) two teaspoonfuls; (B) four or five drops; (C) one-half pint; (D) none.
- _____ 6. When testing braking action of a new departure brake and the pedal does not take hold either forward or backward, it is likely that the (A) pedal is broken; (B) transfer spring is broken; (C) brake discs are slipping; (D) hub has been overoiled.
- _____ 7. It is estimated that coaster brakes are designed and built to withstand wear without repair for about (A) 100 miles; (B) 500 miles; (C) 1000 miles; (D) 2500 miles.
- _____ 8. A mechanic confronted with the problem of silencing a squeaky coaster brake should (A) oil brake with number 20 oil; (B) remove and replace brake shoes or discs; (C) remove and replace hub; (D) remove and replace wheel cones.

Listing

Directions: List the items called for in each of the following. Select your answers carefully.

1. Six kinds of coaster brakes:

(A) _____	(D) _____
(B) _____	(E) _____
(C) _____	(F) _____

2. Three kinds of coaster brakes that use the "wedge" to derive braking action:

(A) _____	(C) _____
(B) _____	

3. Slippage in a "New Departure" type brake may be caused by:

(A) _____	_____
(B) _____	_____
(C) _____	_____

4. Three types of gears found in a Higgins or Sturmey-Archer hub are:

(A) _____	(C) _____
(B) _____	

5. Two types of gear controls used with Sturmey-Archer hubs are:

(A) _____ (B) _____

Assignment
Sheet No. 18

Covering Units
235-242

DUPLICATING KEYS

Security is one of man's most immediate problems. When one leaves his business, his home, his automobile or other personal possessions, he leaves them securely locked. One might then appropriately say that the world sleeps behind locked doors.

But you, as a general mechanic, must share in the responsibility for your client's security. Your prime duty will be to assist the customer by accurately selecting and cutting the key he needs; however, through your association with him, you will gain information that must be treated as confidential.

This assignment is intended to provide you with the opportunity to study the types and shapes of key blanks, materials from which they are made, and the procedures followed in identifying and selecting appropriate key blanks for duplicating keys.

Assignment:

1. Read the reference listed below.
2. Look through the old keys in the shop and see how many different shapes of key heads you can find. Take note of the various shapes and locations of grooves.
3. Answer the questions below and turn in this assignment by _____.

Reference:

H. National Key Company, How to Duplicate A Key, pp. 1-12.

Questions:

True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- T F 1. The thick edge of the key body is designated as the bottom of the key.
- T F 2. Key racks are made in such a way that keys are stored according to their kind and type so the key maker can locate them more rapidly.
- T F 3. When duplicating a key, there are only three major steps that a person needs to learn.
- T F 4. There are three basic widths of grooves commonly used.

- T F 5. The shoulder of a key separates the head from the neck of the key.
- T F 6. When inserting a key in the key machine the thick edge of the key body is always up.
- T F 7. A key blank is grooved on only one side of its body.
- T F 8. If the numbers, sizes, shapes of the grooves, and the cuts of the top edges of two key blanks match, one may assume the keys to be interchangeable.
- T F 9. Keys should be arranged on the rack according to the shape of their heads.
- T F 10. A diamond-shape head is classified under the hex group because it has no grouping of its own.
- T F 11. The numbers on key blanks are located so they can be read when holding the body in the hand with the head up and bottom of the blank to the right.
- T F 12. The key machine is more accurately called a key duplicator than a key making machine.
- T F 13. The parts of a key machine should be oiled daily when in regular use.
- T F 14. Each key machine has two vises, one of which holds the pattern key, and the other holds the blank.
- T F 15. Keys not having shoulders cannot be cut on key machines.
- T F 16. It is possible to cut as many as three blanks at one time.
- T F 17. Groove shapes may be easily recognized by the shape at the end of the groove on the head end of the blank.
- T F 18. A substitute key blank is one which matches the pattern key in every respect except for the shape of the head.
- T F 19. When very low or deep cuts need to be made in a key, it is first necessary to make a shallow cut with the key machine, then finish the cut with a file.
- T F 20. Auto keys are generally smaller than most other keys.
- T F 21. Automobile keys generally have only two types of heads.
- T F 22. Double-cut type keys cannot be cut on key machines because they tend to slip out of place.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. The part of the key which limits the depth which it may be inserted into a lock is called a (A) neck; (B) shoulder; (C) head; (D) tip.
- _____ 2. When measuring the lengths of key bodies, the keys should be placed together so the lengths will be measured from (A) head to tip; (B) neck to tip; (C) shoulder to tip; (D) hole in head to tip of key.
- _____ 3. The primary reason for using different shaped heads for auto trunk and ignition keys is (A) for ease of identification; (B) because the blanks are not made with identical heads; (C) so key manufacturers can sell more keys; (D) so key makers get more work to do.

Matching

Directions: In the left-hand column is a list of terms. The right hand column contains descriptive drawings. Match the shapes to the terms by placing the letter of the drawing in the blank at the left of the appropriate term.

1.

- | | | |
|------------------------|---|---|
| _____ 1. Round | A | B |
| _____ 2. Hex | | |
| _____ 3. Clover | C | D |
| _____ 4. Oval | | |
| | E | F |
| _____ 5. Pear | | |
| _____ 6. Miscellaneous | | |

2.

- _____ 1. Round
- _____ 2. V-shape
- _____ 3. Square round
- _____ 4. Round V
- _____ 5. Square
- _____ 6. Square V
- _____ 7. Square

Listing

Directions: List the items called for in each of the following.
Select your answer carefully.

1. The five parts of a key:
 - (A) _____ (D) _____
 - (B) _____ (E) _____
 - (C) _____
2. Three metals from which key blanks are usually made:
 - (A) _____ (C) _____
 - (B) _____
3. The seven basic parts of a key machine:
 - (A) _____ (E) _____
 - (B) _____ (F) _____
 - (C) _____ (G) _____
 - (D) _____

4. Five reasons why a key might fail to work:

- (A) _____
- (B) _____
- (C) _____
- (D) _____
- (E) _____

OWNERSHIP, MANAGEMENT, AND PRICING

A large majority of the general repair shops are small, employing only one or two mechanics. In many cases the repairman also constitutes the management. Without careful management, a shop is not likely to be profitable, even if a sufficient volume of work is obtained.

Whether or not you ever become a manager, you will be a more efficient, cooperative, intelligent, and productive worker with some knowledge of the problems and responsibilities of the shop owner.

In this assignment you will have an opportunity to learn about the things for which an owner or manager is responsible and for which the employee should be concerned.

Assignment:

1. Read the references listed below.
2. Check the fire codes in your city to see how often fire extinguishers should be checked.
3. Make an estimate of what your employer must charge per hour for your time if you are to be profitable to him.
4. Answer the questions below and hand in with items 2 and 3 by _____.

References:

- I. Information Sheet No. 1, (this manual).
- J. Information Sheet No. 2, (this manual).

Questions:True-False

Directions: The following statements are either true or false. If the statement is true, draw a circle around the letter "T." If it is false, draw a circle around the letter "F."

- | | | |
|---|---|---|
| T | F | 1. Many small business operators do not know that they are responsible for accidents that occur in their shops. |
| T | F | 2. An owner who provides reasonable protection for those in his shop is not liable for injuries they receive while in his shop. |
| T | F | 3. The law gives the injured party the privilege of determining whether or not an owner has been negligent. |

- T F 4. A slick floor is a hazard which can cause injury, not only to a customer, but also the employees in the shop.
- T F 5. In a mechanical shop one might expect to see grease and hand tools scattered on the floor without considering it a hazard.
- T F 6. Although defective tools may contribute to inefficiency, they are not considered hazardous.
- T F 7. A shop having two or more fire extinguishers is adequately protected against fire hazards.
- T F 8. Class B fires consist of those in oil, grease and gasoline.
- T F 9. Fires in plastic materials are very difficult to extinguish.
- T F 10. The carbon dioxide type of extinguisher is approved for both types B and C fires.
- T F 11. Public liability insurances is for the protection of the shop owner when he becomes injured.
- T F 12. Every shop should maintain a thoroughly equipped emergency room.
- T F 13. No record should be made of injuries unless they appear to be serious.
- T F 14. A shop owner should consult with his insurance company and workman's compensation board to ascertain the types of injuries to be reported.
- T F 15. One can expect to charge a fee for any and all service he renders in a shop.
- T F 16. One may easily lose money on a small job if he spends too much time in selling the job.
- T F 17. It is a generally accepted practice for an owner to take as his salary the money that is left over each week after bills have been paid.
- T F 18. It is the belief that the equipment of many manufacturers can best be serviced on a flat rate basis.
- T F 19. Hourly work rates are about the same in all parts of the United States.
- T F 20. It is not reasonable to expect that flat rate charges can ever be adapted to the lawnmower or general mechanics business.

- T F 21. Key duplicating charges are determined on a flat rate basis.
- T F 22. The basis for computing charge rates for bicycle repair is the same as that for lawnmower repair.
- T F 23. A repairman need not feel obligated to give immediate and courteous attention to his customers as long as his work is of superior quality.
- T F 24. Job tickets are usually made only for the larger jobs of a major type.
- T F 25. Job tickets are so well standardized that most any one of them will suit a small business.
- T F 26. It is not likely that a customer will require the repairman to estimate the completion time of the job.
- T F 27. It is satisfactory for the repairman to make a mental note of the parts he uses when doing a job.
- T F 28. Doing too much free work may result in a business failure.

Completion

Directions: Fill in the blank(s) in each statement with the word(s) required to complete the sentence correctly.

1. An owner may protect himself financially by purchasing an adequate _____.
2. The liability of a shop owner can be reduced considerably if he locates and removes the _____ over which he has control.
3. A grinder should never be operated without a _____.
4. Three ways by which fires are classified are as types _____, _____, and _____.
5. In anticipation of possible employee injuries, the shop owner should purchase _____ insurance.
6. If a serious injury occurs, one should first _____, then render only the necessary first aid.
7. One may determine hourly rates by multiplying the hourly wage paid the mechanic by _____ or _____.
8. If one determines charge rates on the basis of his total operating costs, he must add to his charges a profit mark-up of from _____ to _____ per cent.

Multiple-Choice

Directions: In the space at the left of each statement, write the letter of the item which will provide the correct answer to complete the statement.

- _____ 1. The operator of a grinding wheel should always wear (A) a hat; (B) gloves; (C) goggles; (D) a shop coat.
- _____ 2. Probably the greatest hazard encountered in a repair shop stems from (A) fire; (B) defective tools; (C) grease on floor; (D) tools on floor.
- _____ 3. Water is properly and most successfully used on fires of class (A) A; (B) B; (C) C; (D) D.
- _____ 4. A soda-acid fire extinguisher has a range of approximately (A) 80; (B) 30; (C) 50; (D) 10 feet.
- _____ 5. A foam type extinguisher with a 2 1/2 gallon capacity will discharge in about (A) 2 minutes; (B) 30 seconds; (C) 3 minutes; (D) 1 minute.
- _____ 6. Water should be used on (A) gasoline fire; (B) wood fire; (C) oil fire; (D) electrical fire.
- _____ 7. When computing operating expenses, depreciation is usually computed by the (A) month; (B) day; (C) week; (D) year.

HAZARDS

Owners and operators of small businesses often do not know the extent of the responsibilities that they incur. They feel that if they do the work specified by the customer and pay their bills, they are meeting all of their obligations. However, there are other things to be considered, a fact many businessmen have realized only after it was too late.

If an owner has failed to provide reasonable protection, he can be sued and damages obtained by any person who is injured in his place of business. Of course, it is first necessary for the injured party to prove in court that there has been negligence on the part of the owner.

Obviously, every repair shop owner will want to take every possible precaution for the safety of his customers and employees. Not only should he attempt to make his shop completely safe, but in addition, he should take out insurance so that he will be protected financially regardless of what may occur.

PROPERTY HAZARDS

Some of the safeguards that can be taken by the careful shop operator are easily arranged. Others are more complicated and difficult, and will require constant attention on the part of the owner to insure that the safety rules are being observed.

One of the most important provisions that can be made for the safety of customers and employees is a clean, smooth floor on which people can walk without danger of slipping or stumbling. Law books are full of cases where damages have been granted to persons who have been injured from falls caused by negligence in the care of floors.

The cement floor of a repair shop requires constant attention, because even a small spot of grease can easily result in a severe fall if walked on with rubber soles or heels. It is particularly important to make sure there is no grease or litter on the floor surrounding a pit or stairwell, for a fall at such a point can be extremely serious.

Tools or equipment scattered on the floor, a jack handle left protruding from underneath a car, or similar careless and thoughtless handling of equipment can cause serious injury.

Safety precautions should be taken if the shop operates certain kinds of machinery. Many dangers must be guarded against. A few are mentioned here.

The gearing and belting on lathes must be protected by a suitable guard so that it is impossible for the clothing of the operator or of a customer to become entangled in the moving parts. Grinding wheels should never be operated without a guard, because it is not unusual for these wheels to fly apart. As a result of the high rotation speed, the fragments of the wheel flying through the air may cause fatalities or serious injuries. If any long belts are used to drive machinery, these also must have adequate guards.

The operator of a shop must provide safety goggles for the mechanics who use grinding wheels and rotating brushes, as a precaution against eye injury.

Injuries are often caused by defective tools as, for example, loose hammer heads or mushroomed chisel heads. Not infrequently, the head of a hammer flies from the handle, and anyone standing in the way is likely to be severely injured.

It is essential that all tools be inspected frequently to make sure they are safe to use. Always be sure that jacks, horses, and lifts are in perfect working order and that there is no possibility of their failure, with consequent injury to anyone underneath.

FIRE HAZARD

Probably the major hazard to be encountered in a repair shop is that of fire. Here, again, much education is required because too frequently the operator seems to feel that if he provides one or two fire extinguishers, he has done everything possible to protect the property--his own and that of others--in his establishment. Obviously, he must do far more, both in providing fire-fighting equipment and in taking steps to minimize the hazard.

One of the most important things a shop owner must learn in regard to fire is that there are different types and each has to be treated in a different manner and fought with a different type of extinguisher. Furthermore, even the large fire extinguishers have a rather small capacity and will function for only a few minutes.

There are three general classes of fire, designated as Class A, Class B, and Class C. Fires in ordinary materials, such as wood, paper, upholstery, and rubber are known as Class A. They are most easily extinguished by water, which should be sprayed on by means of a stirrup-type pump rather than thrown on by the bucketful.

Class B fires are those in gasoline, grease, and oils and are extinguished by being smothered with certain chemicals, sand or by other such means. A Class C fire is that which occurs in live electrical equipment. The important thing to remember here is to use an extinguishing agent that is a non-conductor of electricity. If the extinguishing agent conducts electricity, the person using it may get a severe shock and possibly be killed.

Fires in plastic materials have recently been classified as Class D. To date, no effective way of extinguishing them has been found. The average repair shop will not have to cope with fires of this type until plastics are more generally used in manufacture.

From the foregoing it is apparent that you should provide a variety of firefighting equipment, plainly labeled so that you can easily tell the type of fire each is designed to combat.

A popular type of fire extinguisher, and one that is easily carried by means of a handle at the top, is the soda-acid unit. This type is effective on Class A fires when the stream from the hose is directed at the base of the blaze. The 2 1/2 gallon unit will operate for about one minute and has a range of approximately 30 feet.

A cage in the unit holds a quantity of sulphuric acid in the top. Then, when the extinguisher is turned upside down, the acid is mixed with a solution of soda and water, and the resulting gas forces the water from the tank. Contrary to common belief, the soda-acid extinguisher is not of the chemical type, the chemicals being present merely for the purpose of generating pressure, which, in turn, forces the water from the containers.

Another type of extinguisher for Class A fires uses a small bottle of carbon-dioxide in place of the soda and sulphuric acid. This type is placed in operation by inverting it and then bumping it on the ground. That action pierces a cap on the carbon-dioxide cartridge, and the released gas creates the internal pressure which expels the water.

One of the newer methods of fighting both Class A and Class B fires is by means of the foam type of extinguisher. This type contains several different chemicals which are mixed when the extinguisher is inverted, producing a foamy substance. This foam blankets a fire and smothers it since fire will not burn without oxygen. The 2 1/2 gallon size has a range of 30 to 40 feet, and discharges in approximately one minute. In using this type of extinguisher, the stream of foam should be directed lightly on the burning surface. The blanket which is formed should not be agitated; otherwise, air will enter.

A dry-compound extinguisher, designed for use on both Class B and Class C fires and having a range of about 10 feet, contains a chemically processed bicarbonate of soda and an inner cartridge loaded with carbon-dioxide or nitrogen. The content is released by rotating the hand wheel at the top of the unit, and the discharge can be controlled by a valve on the nozzle.

The carbon-tetrachloride extinguisher is one of the most popular and it, also, is approved for use on Class B and Class C fires. The one-quart unit lasts for about 45 seconds and has a range of 20 to 30 feet. This type of extinguisher is usually held in a bracket on the wall and is put into operation by turning the handle and using it as a pump.

The carbon-dioxide type of extinguisher, approved for use against Class B and C fires, holds liquid carbon-dioxide under high pressure. When the extinguisher valve is opened, the pressure is released and the liquid carbon-dioxide on contact with air turns into gas and has a blanketing effect on fires by excluding oxygen. In using this type of extinguisher, the gas should be directed at the base of the fire. If the fire is in a wall panel or other vertical surface, the fire at the base of the panel should be extinguished first, and then the discharge should be directed slowly up the wall.

All types of fire-fighting equipment should be inspected frequently to insure that they are in good working order.

TYPES OF INSURANCE

To achieve full protection against accidents and other hazards in the conduct of your business, be sure that you have all necessary types of insurance. Discuss your business with a reliable insurance broker, who will advise you regarding the kinds and amounts of insurance that you require.

In general, the types of insurance found adequate to cover hazards in repair shop operation are public liability, workmen's compensation casualty, fire, and theft.

Public liability will cover any accidents that happen to customers when they are on your premises. For instance, if a customer should slip and injure himself while in your shop, the damages awarded him by the court would be taken care of by your public liability insurance. This insurance is an important safeguard, since your action in operating a shop may be construed as an invitation to the public to enter with the assurance of safety. Public liability also covers damage or injury that might be caused by your truck or other equipment used away from the premises.

Workmen's compensation insurance is designed to compensate workmen for any injuries received while on a job. It is required by law in most states when a certain minimum number of workmen, usually three or four, are employed, unless the employer can show financial ability to pay compensation awarded in the case of his workmen being injured or killed in the course of their work. However, it is a protection for you against claims, regardless of the number of your employees.

Casualty insurance covers the risk of damage to such property as buildings, machinery, fixtures, boilers, and plate glass. The value of fire and theft insurance is obvious.

INJURIES

Probably few of even the largest shops could maintain a thoroughly equipped emergency room; however, every shop should be prepared to furnish emergency first aid to the injured.

The first-aid kit should be fitted out as recommended by the American Red Cross. It should be replenished immediately after being used, and its contents checked once a month or more often. These supplies must, of course, be kept clean. Cases for first-aid supplies preferably should be made of metal or glass and be so constructed as to exclude dust.

The effects of an accident may be intensified through lack of immediate and proper care. On the other hand, unskillful handling of a severe injury may do further harm besides causing unnecessary pain. Therefore, the first thing to do in case of a major accident is to get a doctor. Pending his arrival, no first-aid treatment should be given beyond the necessities of the emergency.

Every injury that occurs, no matter how trivial, should be noted in a record book kept along with the first-aid kit. All cuts, scratches, and bruises should be recorded as soon as they have received attention. Any injury involving lost time requires a more formal report. Such a report usually gives the name of the employer for whom the injured worked and industry, the name, age, sex, and occupation of the worker, cause of injury and designation of the part of the body injured, steps taken to prevent similar injuries and other pertinent data.

As a rule, workmen's compensation laws require the reporting of industrial injuries to the appropriate workmen's compensation board. Some of these boards require the reporting of all injuries, including those involving only first aid; others, all disabling injuries; still others, only those injuries which exceed the waiting period. Therefore, you should ascertain the requirements of the compensation act applicable to your employees and comply fully with those regulations.

If you carry your compensation insurance with an insurance company you should, of course, learn the company's requirements for reporting injuries and abide by them.

JOB MANAGEMENT AND PRICING*

The success or failure of a general repair shop is dependent on many factors. Among the most important, and ones that directly affect customer good will, are prompt attention to the incoming customer and the careful recording of all work ordered.

It is essential, therefore, that someone be on hand to give the customer immediate and courteous attention and see that he is served as promptly as possible. Only by careful attention to the job from the time it is accepted until it is completed can you be sure that the customer will feel that his money is well spent. There is no better way to keep his patronage and, at the same time, safeguard your profit.

RECORDING INCOMING JOBS

In the small shop it is usually the owner who gives attention to the incoming jobs. In the larger shop this task is delegated to the service salesman.

To insure that none of the items of repair ordered by the customer are overlooked and that all work is paid for, it is necessary that a detailed record be kept of the repairs authorized. Most shops use the job ticket or shop order for this purpose and it is one of the duties of the owner or service salesman to make sure that the ticket is filled out in detail.

The repair order or job ticket constitutes an actual contract between you and the owner and binds you to do a certain amount of work. Care in filling out the job ticket will prevent any misunderstanding later as to the amount of work for which you are contracted.

If you fail to do all of the work agreed upon, the owner can hold you responsible. On the other hand, if you do more work than was originally contracted for, you cannot force the owner to pay for the additional labor.

There are many different types of printed job tickets available, some designated especially for the large shops and others for smaller ones. They can be obtained from companies manufacturing business machines, from specialty printers, or from the companies from whom you may be purchasing fuel and lubricants. It is advisable that you study the various forms and select the type best suited to your particular business.

* Abstracted from Establishing and Operating an Automobile Repair Shop, U. S. Department of Commerce, Bureau of Foreign and Domestic Commerce, (Washington, D. C.; Government Printing Office, 1946).

The type job ticket used in large shops is usually made out in triplicate. The first two copies--one white and the other in color--are printed on thin paper and the third on heavy cardboard. The first copy serves as the customer's invoice, the second goes to the repair shop's accounting department, and the third is given to the mechanic assigned to the job so that he will know what repairs are to be made.

Usually, the job tickets provide places for the name, address, and telephone number of the owner, the date when the work was received, the time and completed job is promised, and important facts such as make, motor number and other identifying characteristics.

The major portion of the job order is devoted to listing the various repairs that are to be performed. If the repair shop is operating on a flat-rate price basis, the repair operation number should be noted and the job should be described briefly. There is space provided for writing in the labor charges for each operation and the words "estimates for labor only, material additional" are usually included near this space. This explanation is important as it is impossible in most instances to estimate all parts that will be required for a particular repair job.

Space is provided for the owner's signature and a statement similar to the following is usually included: "It is understood and agreed that this company assumes no responsibility for loss or damage occasioned by fire, theft, demonstration, delivering, and/or calling for any property placed with this company for storage, sale, repair, or otherwise."

Unless such conditions are included the owner can be awarded compensation for damage to his property resulting from fire or other accidents while it is in possession of the shop.

Some forms also include the following conditions of sale: "If, while above work is being performed, additional work is found to be desirable, this company will obtain customer's approval for same." "No claims will be considered unless presented within five days after delivery." In signing the job ticket, the customer agrees to these conditions.

On two copies of the job ticket, space is provided for listing all parts used in making the repair and their prices. The list of parts can be obtained from the requisition forms made out by the mechanic who did the job. The total cost of the parts is added to the labor charge on the face of the order to indicate what the customer shall pay.

All three copies of the job order are identical except the repairman's copy which has space for entering the time of the beginning and completion of each repair operation.

Whether stamped in by a regular time clock or written down by the shop owner or foreman, this information is particularly important

where the repairman is paid on a flat-rate or some other basis involving the actual time required for the repair operation. It may also be of value in determining the relative efficiency of the various repairmen as it constitutes a record of the time they require to do the different jobs.

Upon completion of the work, the third copy of the job order is sent to the accounting department so the repairman's pay may be calculated.

The form described above, since it is to carry all the information required by large shops, is unduly complicated for use of the shop owner employing only a few men, particularly if they are paid a straight weekly salary. The smaller shops use a simpler form, a single copy of, at most two copies, to serve the same purpose.

When this simpler type of job order is used, one copy is given the customer and the other is retained by the shop to supply the information needed by the repairman assigned the job and by the accounting or bookkeeping department.

ASSIGNING AND CHECKING WORK

The shop foreman or owner, as the case may be, must assign work to the repairmen. Naturally, if there are a large number of employees, some will be found to be more skillful than others on certain types of repairing. Therefore, when possible, jobs should be assigned to the mechanics best fitted to do them. In a small shop, assignment of work should not be much of a problem because, presumably, any repairman hired would be capable of turning out a good job in all phases of work.

The responsibility of making work assignments involves seeing that repair jobs are completed on schedule.

It is essential that the job be ready for the owner at the time recorded on the job ticket. If the shop fails to live up to its agreement, it will probably lose trade. It is up to the service manager of a large shop or the owner of a small establishment to make careful note of the delivery promise with respect to each job, and to see that all such promises are kept.

It isn't enough to have the delivery time written on the job sheet. A record of the time promised should be kept in plain view, on a blackboard or otherwise, for all the jobs. In general, the only information required for such a record is the name of owner and the date and time promised.

Keeping a record of this sort has another distinct advantage in that it will help to discourage the person who takes the order from promises that cannot be kept. In other words, if a shop has only one mechanic, the operator should not promise any more work than can be performed by that one mechanic.

CONTROLLING FOR PROFIT

Too frequently, the shop operator neglects to include all charges when he makes up the customer's bill. It should be remembered that failure to include the price of parts, lubricants, or other materials used on a repair job can change a profitable transaction into a loss. Repairmen should be impressed with the importance of noting down, on requisition blanks or in the spaces provided on the job ticket, all parts and materials required for each piece of work.

An accurate record of the time the individual repairman takes to do various jobs assigned him is important not only because the data are needed in fixing charges to the customer but also because of the growing use of incentive pay methods based on actual work time. Therefore, time clocks, formerly found only in the larger shops, are coming more and more into use.

If a shop operator does not feel justified in going to the expense of purchasing a time clock, he must then write in on each job ticket the time the repairman starts and finishes each job. Unless this time is checked in each case with the repairman, this method may result in disagreement between the repairman and operator.

FREE SERVICE AND UNPRODUCTIVE TIME

The owner of a repair shop soon finds that he is expected to give many small services on which there is no definite charge. Free service mounts up, however, and too general a practice of not charging could result in business failure. On the other hand, the good will gained by free service should not be overlooked. The shop owner will have to weigh the value of this good will against the time lost on such jobs, however, free service can be avoided to some extent if, at the time the job is accepted, the repairman will suggest all the work that is required to overcome the trouble.

To ascertain the amount of time they give away, some shop owners periodically record all such transactions carried on during several consecutive days. They are then in a better position to know how much time is lost through free servicing and to decide what to do about the problem.

Unproductive time in a shop can cause considerable loss of profit. Among the factors that can cut deeply into a shop's capacity are lost tools, defective or inadequate equipment, lack of mechanical knowledge, lack of intelligent management, and failure to order necessary parts and to have them ready when needed. Another factor is the time spent in selling a small job that could otherwise have been devoted to selling a complete one. Such haphazard selling forces the owner to make repeated trips to the shop for a lot of small jobs when all the work should have been sold and completed on one trip.

COST AND QUOTATIONS

In order to operate a successful shop you must be sure that your charge to the customer is sufficiently high to allow you a profit. Many repair shops have failed because they didn't take into consideration all the expenses that had to be met. Too frequently the dollars left over at the end of a week are looked on as profit even though the rent is unpaid and there are outstanding bills.

It is only when your books have been balanced at the end of your fiscal year that you can determine definitely the extent of your earnings above your salary, but if you fix prices that allow for all cost items, you will lessen the possibility of experiencing a loss.

SERVICE CHARGES*

From the Pacific to the Atlantic, dealers, distributors, and manufacturers cooperated in answering a questionnaire on prices charged and time required for lawn and garden equipment service work.

Mr. Theo. T. Bayer, of the Lawrence J. Meisel Company, in Clayton, Missouri, logically summarized this study in his statement: "To obtain and consolidate various lawnmower repair charges is no easy task, as you probably well know, because there is no standardization on either the repair prices or among the equipment itself, and you get a wide variety of answers. Frankly, our own shop operates on the theory that each job is a special case."

Of the fifteen different manufacturers who replied to the questions, all but one indicated their equipment could best be service charged on an hourly rate basis. Their range of suggested hourly labor charges was \$2.50 to \$3.75 per hour or an average of \$3.10 per hour.

Their reasoning behind the hourly rate basis over the flat rate charge was answered in a number of ways: "because it's impossible to see trouble that might be encountered"... "because you never know what's wrong with a mower until you tear it down"... "too many overlapping jobs to be able to definitely define each individual job"... "give the man who takes care of his mower who cleans and oils it a break because it takes less time to work on"... "most fair to customers"...

Dealers and distributors on the West Coast indicated their hourly charges ranged from \$2.00 to \$3.85.

In small mowers of the 18" to 22" class the flat-rate sharpening charges differed from \$5.00 to \$7.50. On hand lawn mowers a sharpening job range was \$2.50 to \$3.00.

* Service Charges, Garden Supply Merchandiser, June, 1953.
(Reprinted with permission.)

Engine work was mostly on an hourly basis, few attempts made to put it on a flat charge set-up.

Studies from the northeast and east indicates most sharpening work was on a flat rate arrangement and engine or chassis work on an hourly charge, thus most dealers used a combination of flat rate and hourly rate. The average flat rate charge on 18" to 22" lawn-mowers was \$7.50; over 22" was \$9.00, and their hourly charges covered a \$2.50 to \$3.50 range.

The south reports show about a 50-50 percentage of flat rate and hourly rate basis. Hourly rates \$3.00 to \$3.50. Flat rates on 18" - 22" sharpening jobs were \$8.00 average and \$10.00 averaged above 24 inches.

Of six returns from the southwest, all stuck to the hourly rate of \$3.00 to \$4.00 charge--averaging out to \$3.40 an hour.

One distributor among this group said: "Service work is not very profitable due to the lack of experienced mechanics, the great variety of makes and models, and the lack of customer education on service problems and power equipment. Charges are too low at present, but customer reaction won't allow much increase."

As the mid-west gave us the largest returns of the questionnaires, it offers a better cross section of country to city type charge; the listing of all these is put into chart form.

1. Power Lawn Mower Sharpening Only

Size 18-22" -- average flat rate charge -- \$8.62 of 16 reports. (Reports) \$7.50; \$8.00; \$10.00; \$10.00; \$8.50; \$9.50; \$9.50; \$7.00; \$7.00; \$10.50; \$10.00; \$9.00; \$10.00; \$7.50; \$6.50; \$7.50.

Size 24" and over -- average flat rate charge -- \$11.50 of 8 reports. (Reports) \$10.50; \$14.00; \$12.00; \$12.50; \$15.00; \$9.50; \$10.00; \$8.50.

2. Engine Complete Overhauls... Note, these are flat rate charges of complete over-hauls on engines ranging from the small 1 h.p. through 4 to 5 h.p. The smaller sum being on the small 1 1/2 h.p.

Average -- \$16.62 to \$21.50 of 11 reports. (Reports) \$18.00 to \$20.00; \$27.50 to \$32.50; \$15.00 to \$22.00; \$16.25 to \$19.50; \$16.00 to \$17.00; \$15.00; \$16.00; \$12.50 to \$20.00; \$15.00 to \$18.50; \$15.00 to \$22.00; \$12.50 to \$25.00.

3. Hourly Rate Charges Average -- \$3.31 of 15 reports.

(Reports) \$3.50; \$3.50; \$3.50; \$3.00; \$3.75; \$3.00; \$3.25; \$3.96; \$3.50; \$3.00 \$3.50; \$3.00; \$3.00; \$3.50; \$2.75.

4. Hand Lawnmower Sharpening

Average -- came to \$2.56 of 15 reports with three of these as low as \$1.50 to \$1.75, stating competition and the area would not warrant charging more. Two reported a \$4.00 charge.

Thus from the area reports you can get some idea of service charges being made. As to how much a customer should pay for servicing of any lawn and garden equipment the logical answer is... enough to get a good job done by a reputable well-qualified service shop, accepting the fact a fair profit must be allowed.

In order to operate a successful service shop you must be sure your charge to the customer is sufficiently high to allow a profit. Many have failed, or are just existing, because they didn't take into consideration when setting their prices all the expenses that had to be met.

It is only when your books have been balanced at the end of your fiscal year that you can determine definitely the extent of your earnings above your salaries, but if you fix prices that allow for all cost items, you will lessen the possibility of experiencing a loss.

It should be of interest to know that in the automotive repair shops the average approximate profit is 8 per cent of net sales. Naturally, there are some automotive repair shops that have profits in excess of that average, many perhaps below it, and still others operating at a loss.

Determining the hourly rate -- There are two ways of determining the rate for a Lawn and Garden repair shop.

The first method and simplest is based on the hourly wages paid to the servicemen. You multiply the hourly wage paid the mechanics by a factor which ranges from 2 to 2.5.

As an example, suppose you pay your servicemen \$1.00 an hour... to obtain the hourly rate charge to the customer you multiply \$1.00 by 2 or 2.5, thus establishing your hour rate of \$2.00 or \$2.50.

The second method, though more involved, will certainly figure things down to the penny. In this, you divide the total of all the costs of doing business in a month's time by the number of productive hours during the same period. By "productive hours" is meant the total time actually spent by servicemen working on equipment, and would not include, for example, time spent elsewhere.

Suppose that, for a shop employing two mechanics and requiring a small amount of non-productive secretarial help, the itemized cost of doing business is as follows:

Rent	\$100.00
Depreciation	30.00
Salary, two mechanics.	350.00
Salary, non-productive (including owner's)	190.00
Electricity.	10.00
Telephone.	5.00
Mail and advertising	25.00
Bad debts.	10.00
Unemployment and social security taxes	25.00
Miscellaneous.	<u>55.00</u>
	\$800.00

The productive hours, if the mechanics each work 200 hours per month, total 400. Dividing the total cost of doing business--\$8.00 -- by 400 gives \$2.00 as the rate per hour. To this figure there should be added a profit mark-up of from 10 to 15 per cent. The average, or 12 1/2 per cent, mark-up on the base, or cost, figure is 25 cents. The hourly rate is thus fixed at \$2.25.

Most of the items of business cost included above require no explanation. However, it should be pointed out that salaries for everyone in the shop are included. Remember that you should place yourself on the payroll at a definite salary. Taxes include unemployment taxes, social security taxes, and any municipal or other taxes incurred.

If you are renting your establishment, depreciation would include only the depreciation of equipment. The amount would depend on the length of time before the equipment would normally become obsolete. If you have \$1,800 worth of equipment and wish to calculate depreciation on the basis of five years, you divide the amount of worth by 60, (5 x 12 months) which gives \$30 as the monthly depreciation. If you own the building, instead of a rent item you would have real estate taxes, interest on mortgage and on invested capital, and certain expenses for maintaining your building.

Theories presented on flat-rate charges are worth considering for adaptation in the lawn and garden equipment business. In the automotive field charges today for many kinds of repair jobs are fairly well standardized, and it operates very smoothly. Originally, the automotive field charged the customer on a time and material basis, (the way most of our dealers operate today because of the lack of surveys and studies that could assist dealers) but pressure by car owners who wanted to know the cost of repairs before they were actually made forced repair shops to gradually adopt what are known as flat rate prices for most operations. This same desire on the part of lawn and garden equipment owners to know before what it'll cost'em to have their machine fixed is a strong point in favor of someone in this industry of ours undertaking the task of gathering facts and figures for the field to consider and perhaps adopt.

Yes, the automotive dealers tried out such prices rather reluctantly at the start, because they felt it impossible to foretell

accurately how long it would take to do a job. However, experience soon indicated that charges could be established which were fair both to the repair shop and the equipment owner.

It's true that the time required to do repair jobs of the same kind may vary, but the variation is small and the advantages of being able to quote a price to a customer for his consideration and approval before the work is performed are far greater, at least in the thinking of the automotive field, that flat rate prices are now charged by virtually all auto shops.

They say flat-rate prices have been established in the automotive field for 80 to 90 per cent of all the repair operations done. For the few remaining jobs which cannot be given a flat rate price, the charge is then based on actual time and material. This offers our field a challenge to work out a similar policy. The cooperation of the interested manufacturer, the distributor and the dealer, could easily work it out.

All must keep one important fact in mind and that is, if the lawn and garden equipment service shop is to be successful, if it is to contribute to the service needs of the community that it serves, if it is to grow and improve... it must be able to operate at a profit on labor as well as on parts. Give serious study to your service shop charges.

Bicycle repair prices are determined similar to those of lawnmower repair prices. The shop operator must first determine what his expenses will run and compute the value of his time on that basis following the example that was given above.

Key duplicating work is strictly piece work, and the price will be determined by the type of key blank used. Usually, the prices will run from 25 cents up with the average key, such as the auto ignition key, running about 35 to 45 cents depending on the location of the shop and the operating expenses.

TRAINING PLAN AND PROGRESS RECORD
FOR
GENERAL MECHANICS

JOB TRAINING: What the Worker Should Be Able to Do	Proficiency Shown	RELATED INFORMATION: What the Worker Should Know
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Engines

Diagnose and repair troubles in fuel, electrical, lubrication, and power systems



Nomenclature and principles of operation of different engine components

Time in hours _____

Lawnmowers

Diagnose troubles, repair, sharpen and adjust



Names of parts, principles of operation, and adjustments of reel and rotary mowers

Time in hours _____

Chain Saws

Diagnose troubles, repair, sharpen and adjust engine and chains



Names of parts, principles of operation, adjustments necessary to repair of engine and chain

Time in hours _____

Outboard Motor Lower Units and Propellers

Inspect, install, replace, lubricate and repair lower units, clean and care for motor



Principles, types, kinds and theory of lower units, propellers and lubricants

Time in hours _____

Bicycles

Diagnose, repair and adjust



Components, principles and adjustments

Time in hours _____

Keys

Identify and duplicate keys



Types of blanks, their identity, and materials from which they are made

Time in hours _____

Business Management

Receive, record and estimate repair costs for incoming jobs

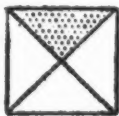


Responsibilities of management, hazards, job pricing, estimating and record keeping

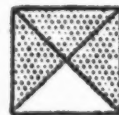
Time in hours _____

Code for employers use in marking student's progress:

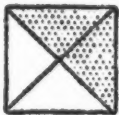
Performed some operations in area



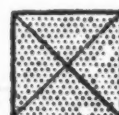
Performed some operations with reasonable proficiency



Performed most operations in area



Performed most operations satisfactorily



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Components, principles and adjustments

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Keys

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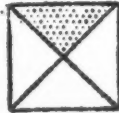


Responsibilities of management, hazards, job pricing, estimating and record keeping

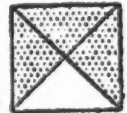
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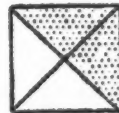
Performed some operations in area



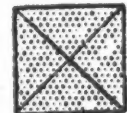
Performed some operations with reasonable proficiency



Performed most operations in area



Performed most operations satisfactorily



TRAINING PLAN AND PROGRESS RECORD FOR GENERAL MECHANICS

JOB TRAINING: What the Worker Should Be Able to Do	Proficiency Shown	RELATED INFORMATION: What the Worker Should Know
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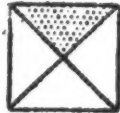


Responsibilities of management, hazards, job pricing, estimating and record keeping

Time in hours _____

Code for employers use in marking student's progress:

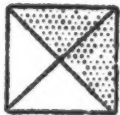
Performed some operations in area



Performed some operations with reasonable proficiency



Performed most operations in area



Performed most operations satisfactorily

